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POWER

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Interest

DO YOU ever get into the doldrums or dumps; when life seems dull and drab and nothing appears to be worth while?

What a boon it is, when you are in such a condition, to be able to find something in which you can take a real live interest.

When you have lost your interest in a thing, it becomes a task. You neglect it if you can, take it up with an effort if you must, and work at it perfunctorily and without attention to its best possibilities.

It has got to be done, you have got to do it and you go at it because you must, with the idea of getting it done passably as soon and as easily as possible.

If you have a real interest in it, you go at it because you want to, because you would be thinking about it and planning it out and wondering about it even if you could not get at it.

And when you go at a thing in this kind of a spirit, it not only gets done, but gets done well, You get the most out of it and become a success at it.

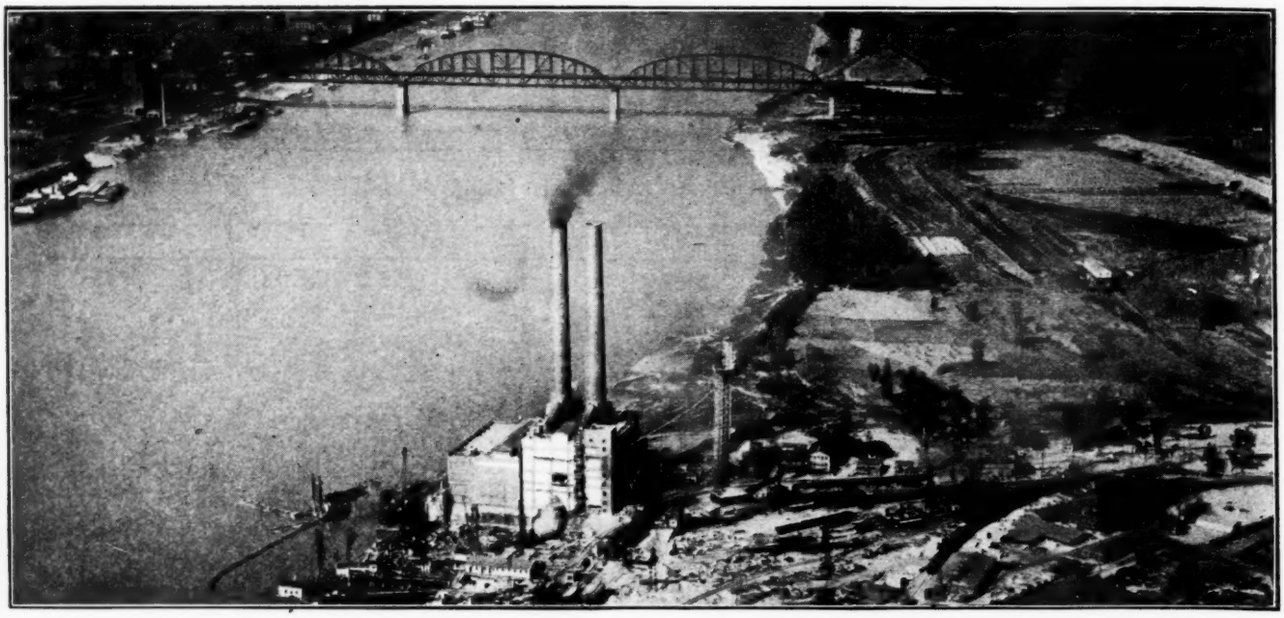
There is no limit within the humanly possible to what one can accomplish if one has interest enough and time enough. Mediocrity comes from lack of interest and application; genius and accomplishment through interested endeavor.

The boy who takes up music or acting or engineering or science because of the salaries or fame that celebrities in these fields attain, will not achieve any large degree of success unless he develops a real love for and interest in his chosen subject.

And the greater this love and interest the greater will be the concentration and intelligence with which he will pursue it, the more he will become a craftsman and artizan, a master and a genius.

Your employer or the one who is responsible for you, the one the success of whose business or department is dependent upon or affected by your efficiency and effectiveness, is probably watching you. If he is not, you need a new employer or boss.

F. R. Low



Cahokia Station, Union Electric Light & Power Company, St. Louis, Mo.

PROBABLY few large central stations have created more interest in the engineering world than has the Cahokia Station of the Union Electric Light & Power Co., St. Louis. This being the second large central station to adopt pulverized coal as fuel and the decision being made at a time when plans were under way for several other large central stations in different parts of the country in which stokers were to be installed, caused more than the usual amount of interest to be taken in the design and operation of this station. Although not entirely complete, the first section of the plant, consisting of two 30,000-kw. units, has been in operation for several months and the work of extending the building for the next two units, which will have a total capacity of 65,000 kw., is already far under way. The station is operated in parallel with the Ashley Street steam plant and through a frequency changer with the hydro-electric plant at Keokuk, Iowa, and serves as a base-load station for the 60-cycle system.

The plant is situated on the Illinois side of the Mississippi River opposite the City of St. Louis and a few hundred feet south of the city limits of East St. Louis, between the government levee and the river. This location affords excellent railroad facilities and accessibility to the center of coal supply, and by obviating bridge and switching charges makes possible a saving of 29 cents a ton on the coal. It is also much nearer the center of load than any other site now available on the Missouri side of the river. Contrary to the usual practice on plants situated along rivers, in which the station is built some distance back from the river, necessitating fairly long circulating water tunnels and in some cases a river wall as well as a waterproof building wall, the station at Cahokia is placed partly in the river, with the wall of the plant on the inner harbor line.

LOW-GRADE coal, location of plant and indicated operating economy responsible for adoption of pulverized fuel. Preparation plant in same building as boilers and flue gases utilized to dry coal. Each section of station containing two turbo-generators and eight boilers is an independent unit to permit taking advantage of advances in the art of design of future sections. Steam pressure 300 lb., temperature 690 deg., natural draft, no economizers. Filtration, chemical treatment and evaporators employed.

It was necessary to provide for a difference of approximately 45 ft. between extreme high and extreme low water level. The soil conditions at this point made it advisable to support the entire plant on concrete piles. The site consists of about fifty acres of low ground, practically all of which is made land; that is, sand and silt deposited by the action of the river during the last forty years.

In connection with the construction work it was necessary to build levees and cofferdams on the north, south and west sides of the site to an elevation above high water. These connect with the government levee on the east and carry permanent tracks and roadways. To complete this work, to raise the site to the established yard grade immediately adjacent to the station and to improve condensing-water intake conditions, approximately 900,000 cu.yd. of material was dredged from the river bed.

The first section of the station, which extends approximately 230 ft. along the river by 235 ft. in width, is supported on about 3,000 reinforced-concrete piles grouped and spaced according to the amount and distribution of the load imposed by the structure and equipment. The piles under the turbine room, electrical bay and river bay are precast type and were driven and jetted down with 250 lb. pressure to a firm bearing in the gravel stratum, then a reinforced-concrete mat

4 ft. thick was placed on top and tied to each pile by steel bars engaging the bars in the piles. The concrete piles under the boiler room are cast-in-place type. To provide against the possibility of water entering the building through the mat and walls, a waterproofing membrane of asphalt and fabric has been provided in all floors and walls below grade 40. The river wall

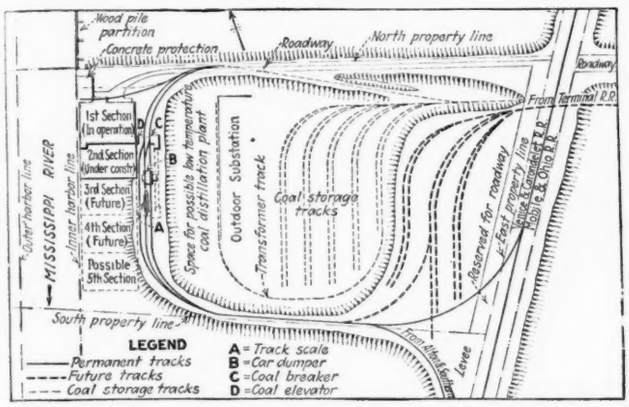


Fig. 1—Plot plan showing location of plant in relation to river, coal storage and railroad facilities

is constructed of precast interlocking concrete sheet piles each about 75 ft. in length and weighing approximately 15 tons.

As indicated in plot plan Fig. 1, the ultimate plant will probably consist of four complete and independent sections, but the layout provides room on the property for a possible fifth section, a rotary car dumper and coal conveyor being the only pieces of equipment common to two or more sections. The advantages of building a station in sections where each section is a complete plant and independent of future extensions will be apparent, probably the most important advantage being that it requires a minimum of immediate investment and permits taking advantage of improvements in the art in design of each subsequent section.

The boilers, eight in number, are of the B. & W. cross-drum type, each with a total heating surface of 18,010 sq.ft. They are 20 tubes high and 38 wide, with 60-in. drum. Although designed for 350 lb. pressure, the boilers are operated to give 300 lb. at the turbine throttle with a total temperature of 690 deg. They will normally operate at 200 per cent rating, but when necessary, up to 300 per cent rating. Each boiler is equipped with a convection-type superheater placed above the sixth row of boiler tubes.

The selection of 350 lb. as the working pressure was in line with the highest pressure used in large stations at the time the plant was designed, and going above this point was not warranted by the low price of coal to be used.

Each boiler is fired by ten burners located almost vertically in the arch forming the top of the combustion chamber, as shown in the section Fig. 3. The feeders (one for each burner) are mounted directly below the pulverized-coal bins and are arranged in one unit for each boiler and driven by a variable speed direct-current motor. Each feeder is connected to the main drive through a clutch, thus permitting all or any number of feeders to be operated at one time. The vertical distance between the feeder and the burner is approximately 31 ft.

Any coal in the St. Louis district market may be

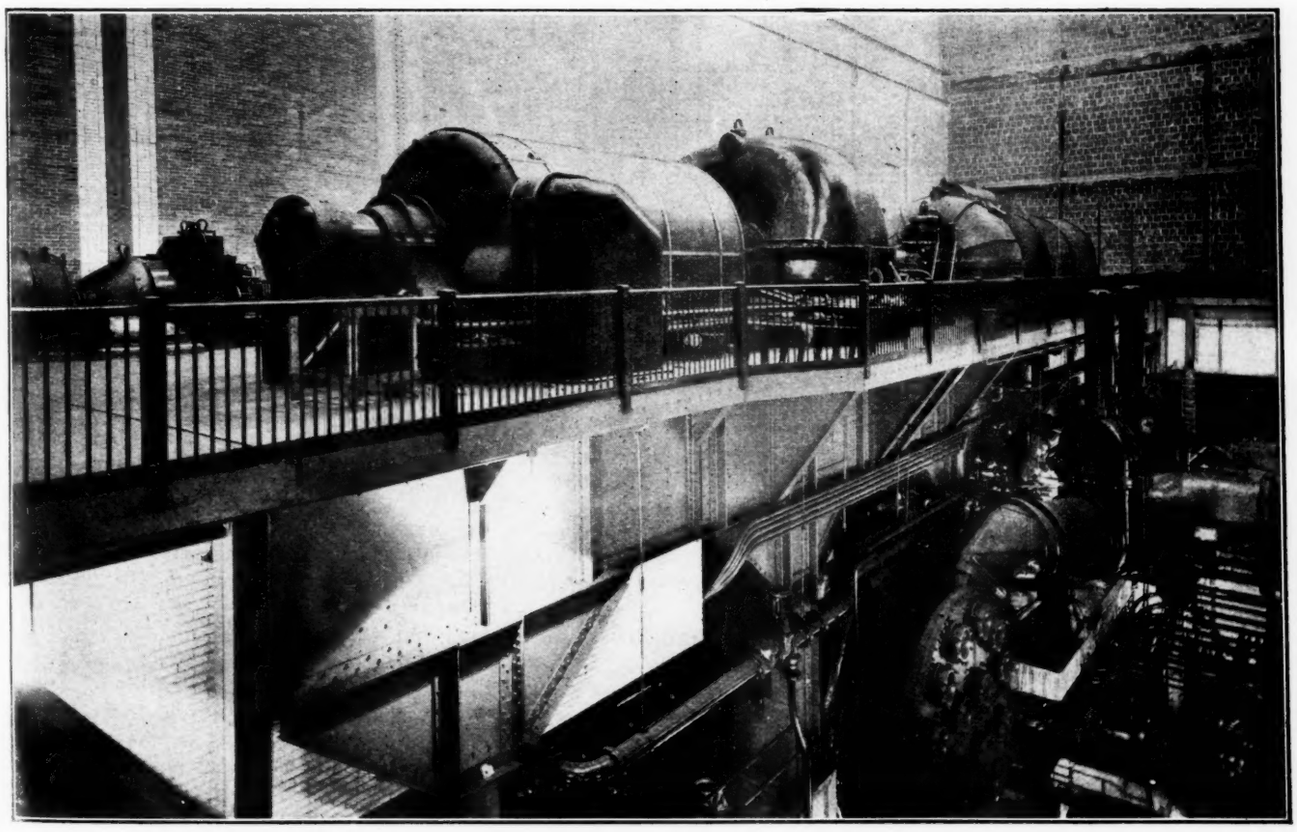


Fig. 2—View of turbine room showing two 30,000 kw. units

burned, but the predominant fuel to be burned is a low-grade coal from the Belleville district, some 20 miles distant from the plant. The proximate analysis of the coal is as follows: Moisture, 12.47 per cent; fixed carbon, 45.91, volatile matter, 37.4, ash 16.69, sulphur, 5.04 per cent. Its heat value as received is 9,945 B.t.u. The fusion point of the ash is 2,000 deg. F.

The furnaces are designed with ample volume and capacity for burning low-grade coal with a long flame characteristic, provision being made for a total flame length of 55 ft. The furnace volume per boiler is 11,440 cu.ft., giving a ratio of furnace volume to heating surface, including water screen, of 0.615 to 1. A cross-section of the furnaces is shown in Fig. 13. They are constructed with hollow side walls through which the secondary air is passed before being admitted to the boiler. Air from the boiler room is drawn into the flues in the wall through openings near the rear of the furnace and caused to circulate through the wall by the stack draft. The air is finally admitted to the furnace opposite the small doors shown in the front wall and through which additional secondary air is admitted. The passage of air through these hollow walls and a water screen built of 4-in. tubes on 10½-in. centers and

about 15 per cent of the total required for combustion, the remaining 85 per cent being supplied as secondary air, as previously described.

For removing the ashes from the pits, cast-iron sluices are attached to the furnace bottoms. The ashes are discharged through hand-operated gates and sluiced into a sump outside of the building where the clinkers drop on entering and the finer ash is pumped out from one end of the sump in one to two hours per day for filling up the land surrounding the plant. The clinkers

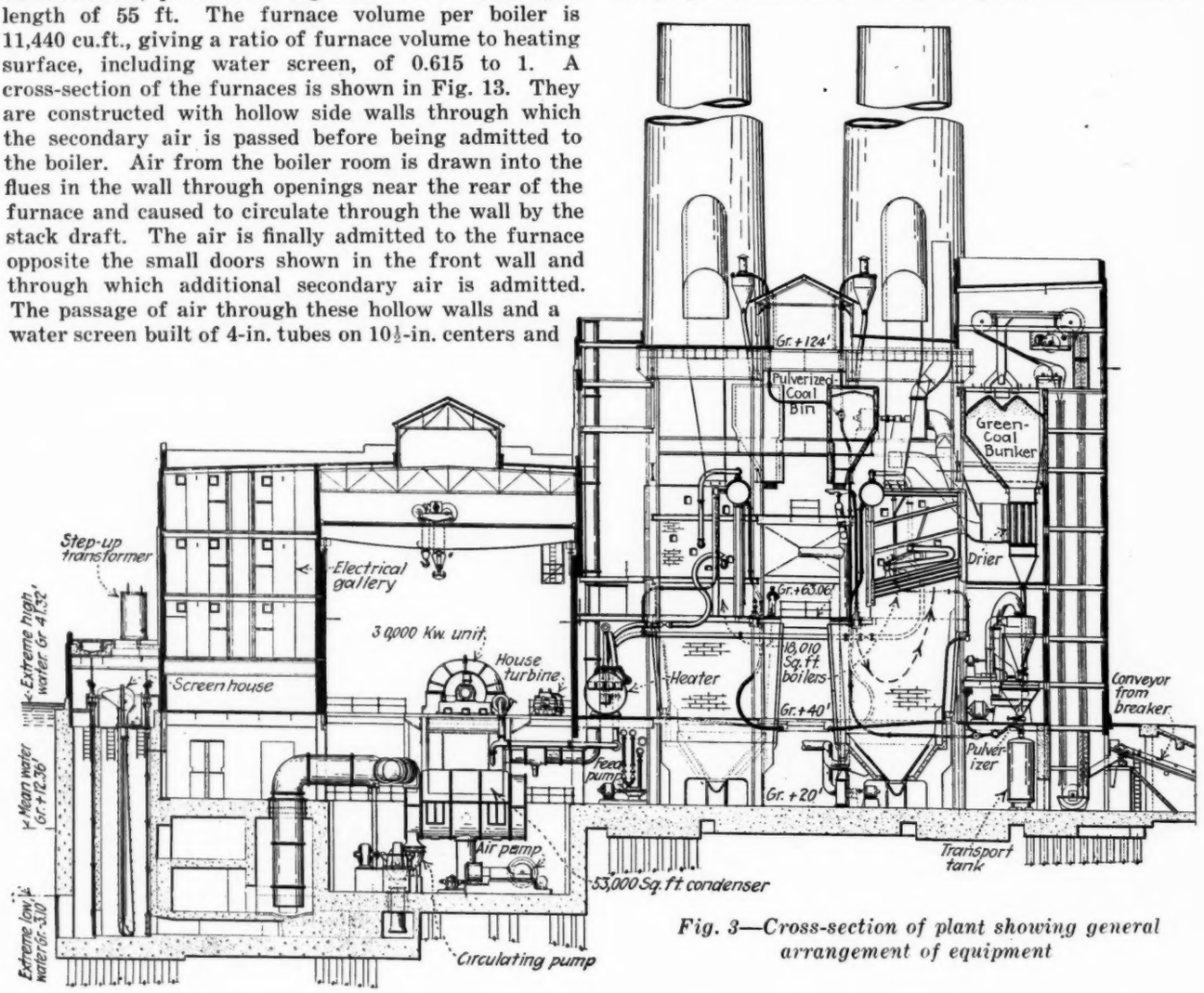


Fig. 3—Cross-section of plant showing general arrangement of equipment

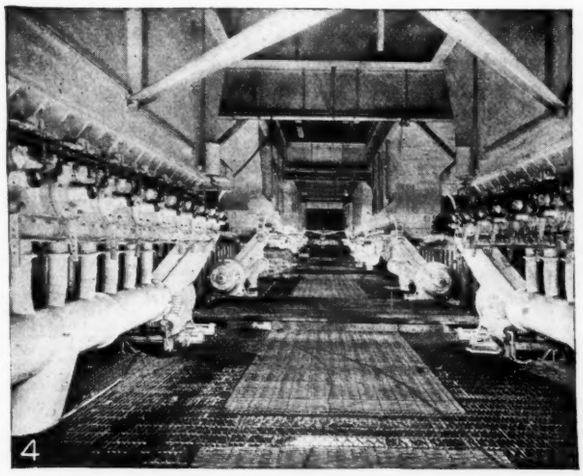
having an effective surface of 580 sq.ft., prevents excessive furnace temperatures and slagging of the ash in the furnace and also protects the major portion of the rear wall (see Fig. 13). It is supplied from the cross-drum of the boiler by two 6-in. pipes. The inlet connection to the screen is taken off each end of the boiler drum at *A*, Fig. 13, and is returned to the drum above the water level.

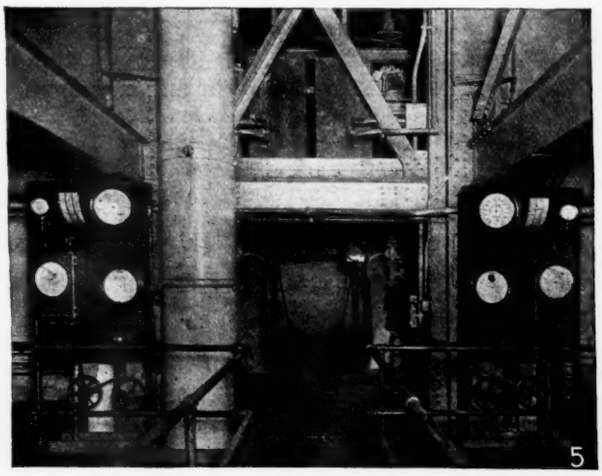
The hopper bottom of the furnace serves as an ashpit, the floor of which is effectively cooled by passing around it the primary air supplied to the coal feeders. There are four 20,000 cu.ft. per min. fans, one for each two boilers, on the basement floor directly below the central aisle, drawing their supply of air through ducts surrounding the furnace bottoms. The air is discharged to a common duct carried along below the feeders. The amount of air delivered to the coal at the feeders is

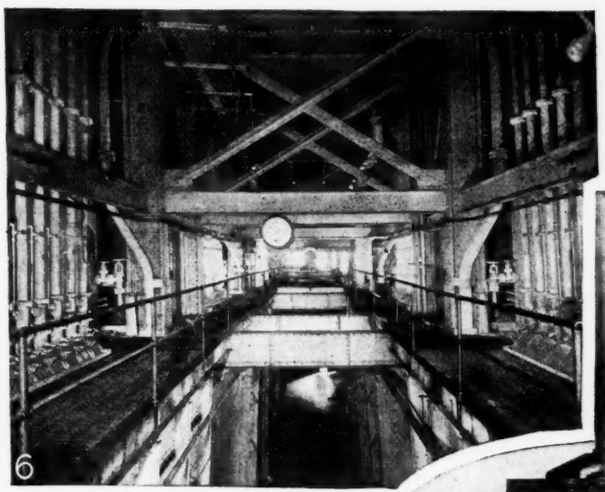
are removed from the sump from time to time by a grab bucket and loaded into cars; so far this has been necessary only about once a month.

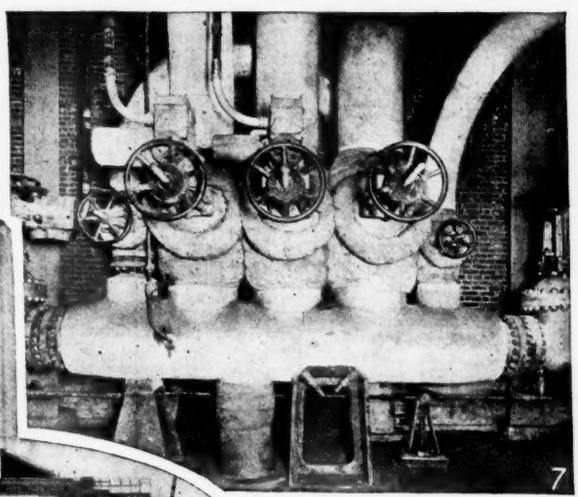
Each row of four boilers has a single stack and two breechings, the former in the center with two boilers on each side. The stacks are of reinforced tile concrete construction and are superimposed on the building structure. They rise 325 ft. above the burners and have an internal diameter of 19 ft. at the top.

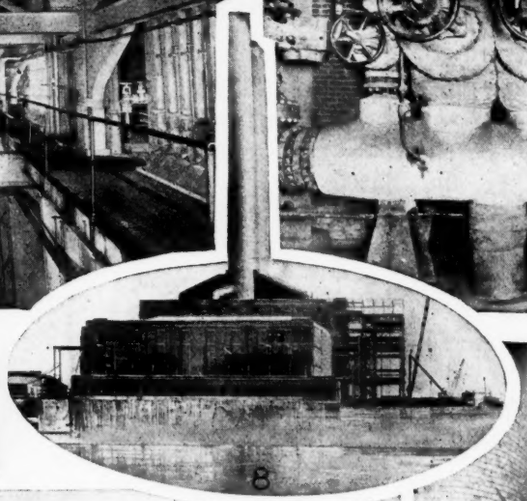
The quality and prices of the coal that will be normally used did not warrant the installation of economizers. However, space is available above the boilers for them and for induced-draft fans on the roof if at any future time the price of coal and operating conditions should warrant their installation. The plant design permits firing the boilers in the future extension with stokers or gas or fuel oil if desirable.

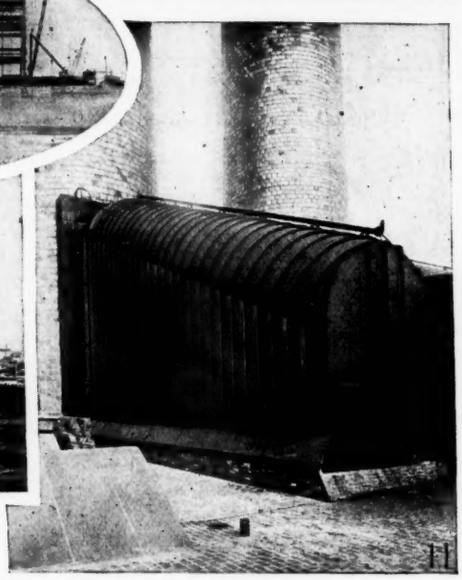












General Views of Station and Equipment

Fig. 4—Central aisle between boilers at feeder level. Fig. 5—Control panels located along side of boiler at burner level. Fig. 6—Central boiler aisle at burner level. Fig. 7—High-pressure steam manifold. Fig. 8—View of plant looking from river, shows second section of plant under construction. Fig. 9—Central aisle between furnaces at grade 40. Fig. 10—Rotary car dumper. Fig. 11—Tile-concrete stacks and breechings

The boiler room is under the direction of a boiler-room supervisor with the control for each four boilers near a central point and also near the individual boilers in the group. At present only two of the boilers are equipped with an automatic combustion control. The control functions with the variations in the stream pressure and regulates in relative proportion the speed of the coal feeders, the natural draft on the furnace and the opening of the dampers admitting the secondary air to the furnace.

As previously stated, two generating units have been installed, each having a capacity of 30,000 kw. at 85 per cent power factor. Unit No. 1 is a 17-stage impulse machine, and No. 2 is a semi-double flow reaction machine. The units are placed with their axes in line and approximately in the center of the turbine room. This arrangement permits of a turbine room 58 ft. wide between column centers, and thereby reduces the cubical contents of the building per kilowatt installed. The turbine-room floor is in reality only a platform about four feet wide along each side of the machines. This fills all conditions necessary for proper operation and allows an abundance of light and air to reach the condenser floor and station service floor where most of the auxiliary equipment is located. In addition to the two main units there are two 2,000-kw. house turbines principally for starting up and emergency power. Their function in the heat balance is described in a later paragraph.

The condensers are of the two-pass surface type with 53,000 sq.ft. of cooling surface, which reduces to 1.75 sq.ft. per kilowatt of generator rating. They are directly below the turbine exhaust and are provided with expansion joints. Circulating water is supplied by two 33,000 gal. per min. pumps, with bottom suction and equipped with hydraulically operated valves. When operating together, the pumps have a combined capacity of 54,000 gal. per min., giving a maximum ratio of 1.8 gal. of water per minute to each kilowatt installed. Each pump is direct-coupled to a slip-ring induction motor. Except for possibly a short time during the summer, when the temperature of the river rises to around 87 deg., one pump will be capable of producing an economical vacuum.

For removing the condensate from the condensers two 6-in. two-stage motor-driven pumps are provided; Each pump has a capacity of 800 gal. per min. at 225 ft. head. A rotative dry-vacuum pump driven by a 50-hp. motor through a silent chain is also part of the condenser equipment.

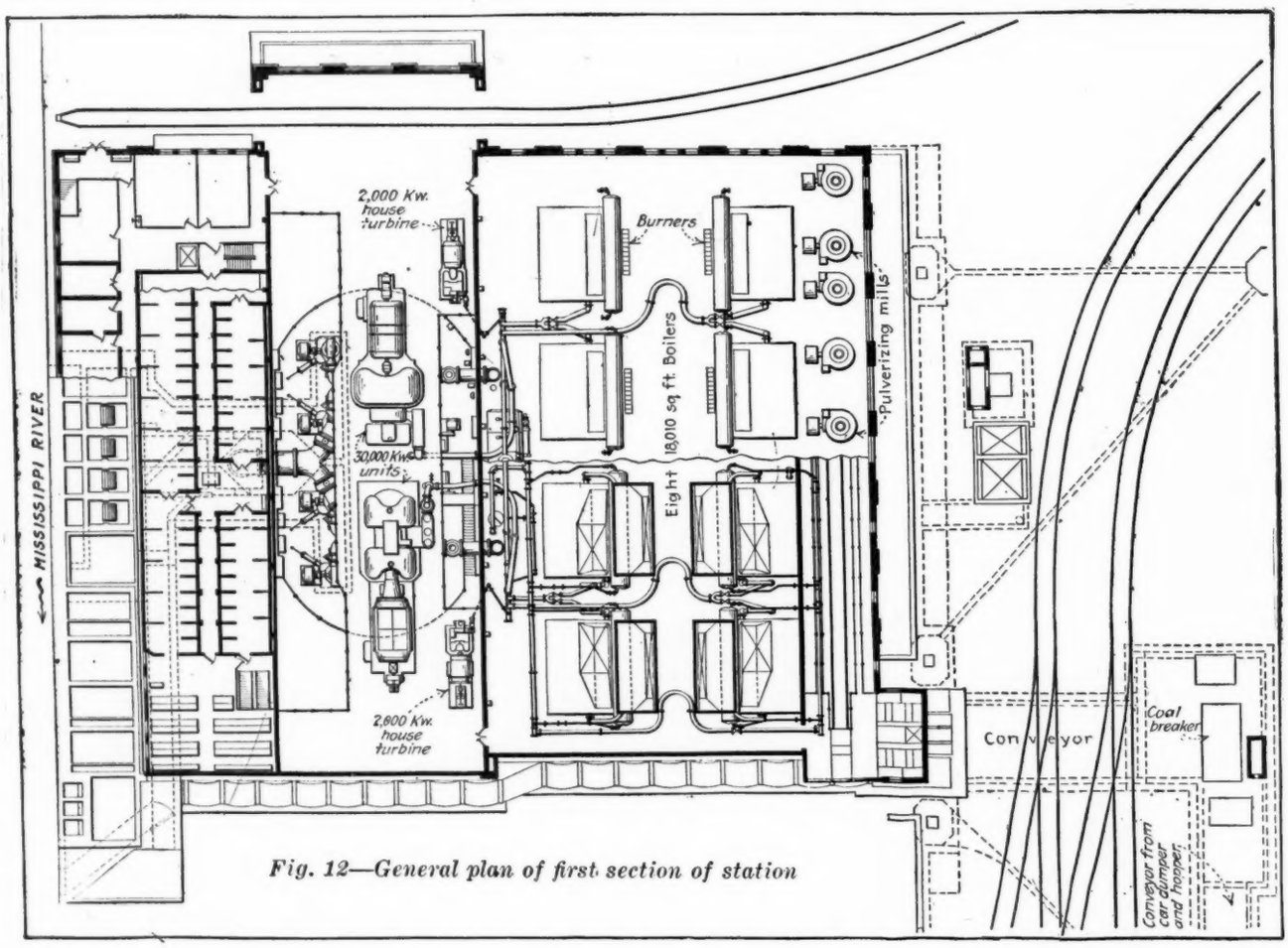


Fig. 12—General plan of first section of station

Owing to the wide variations in the river-water level the condensers are located in a single oval-shaped well, the floor of which is approximately 42 ft. below the operating platform of the main units.

An interesting feature in connection with the construction of this pit is the method employed of waterproofing the floor and walls and also of bonding the surfacing concrete and mat together.

The latter was done in order to utilize the weight and strength of the mat plus the piles to resist the upward pressure which at high water amounts to over 2,500 lb. per sq.ft. The bond was obtained by keying

the surfacing concrete to the mat on the top of the piles by a dovetail construction. The dovetails were formed in the mat, the waterproofing was then applied to follow the contour of the dovetails and finally the surfacing concrete was poured directly on the waterproofing, thus completing the keying. A similar construction is used for the walls wherever there is water pressure.

The circulating-water system, including tunnels and screenhouse, is inside the building structure. This was made possible by placing the river wall of the building on the inner harbor line. The system is laid out with twin intakes and a common discharge, and both traveling screens and trash racks are installed.

The ability to burn any grade of coal and mine sweepings economically in pulverized form and the increased efficiency of combustion were two of the main factors in committing this station to the use of pulverized fuel. The decision was reached only after exhaustive tests and investigation had been made by the engineers. A series of tests were conducted with the coal that will be chiefly used at Cahokia, on three different types of forced-draft chain-grate stokers in regular operation at central stations in the Middle West. These stokers were selected as best adapted to that particular coal. Similar tests were also conducted at the Lakeside Station at Milwaukee using the same grade of coal in pulverized form.

Tests Showed Four Per Cent Less Coal Consumption with Powdered Coal

Upon computing the tests and reducing them to a common basis, the average of these tests early in 1922 on pulverized coal showed approximately 4 per cent less coal consumption than the best test with the stoker. Specifications were prepared and competitive proposals secured on stokers and pulverized-fuel equipment, and a tentative layout was made of the plant to ascertain which would require the more space, and the conclusion was reached at that time that the fixed charges on the building and equipment combined would be about the same for stoker and pulverized-fuel equipment.

The operating results and other tests at the Milwaukee station were studied over a considerable period, and the maintenance cost of the equipment was also given careful consideration.

Other advantages of pulverized coal as fuel under the Cahokia conditions were, the purchasing advantage of mine sweepings and low-grade coal, the small banking loss and quick pick-up for sudden changes in load and the possibility since realized of using a 38 wide boiler instead of a 44 wide boiler required by the stokers under consideration to secure grate area. The net cubic feet of boiler plant (including external coal handling and preparation) per square foot of boiler-heating surface (exclusive of water screen) is 15.9 for the first section and 12.5 for the second section.

Coal as received from the mines is first weighed on track scales of 100-ton capacity and then handled by a rotating car dumper or dumped directly into a hopper beneath the auxiliary track. From the hopper the coal is conveyed on a 36-in. wide inclined rubber belt to the feeding hopper of a Bradford breaker of sufficient capacity for one-half of the ultimate station. In passing through this breaker the coal is reduced to 1¼ in. size and under, the finer coal passing directly to a belt conveyor while the tailings are carried to a swing-ring crusher, where they are reduced to 1 in. and under. The crushed coal, together with that passed through the breaker is carried by inclined belt conveyors and discharged to two bucket elevators. The head pulleys of the conveyors serve as magnetic separators and remove the tramp iron from the coal.

With the exception of the rotary car dumper, which has sufficient capacity for the ultimate station, the coal-handling equipment up to this point was located underground. This was done with a view to leaving the yard

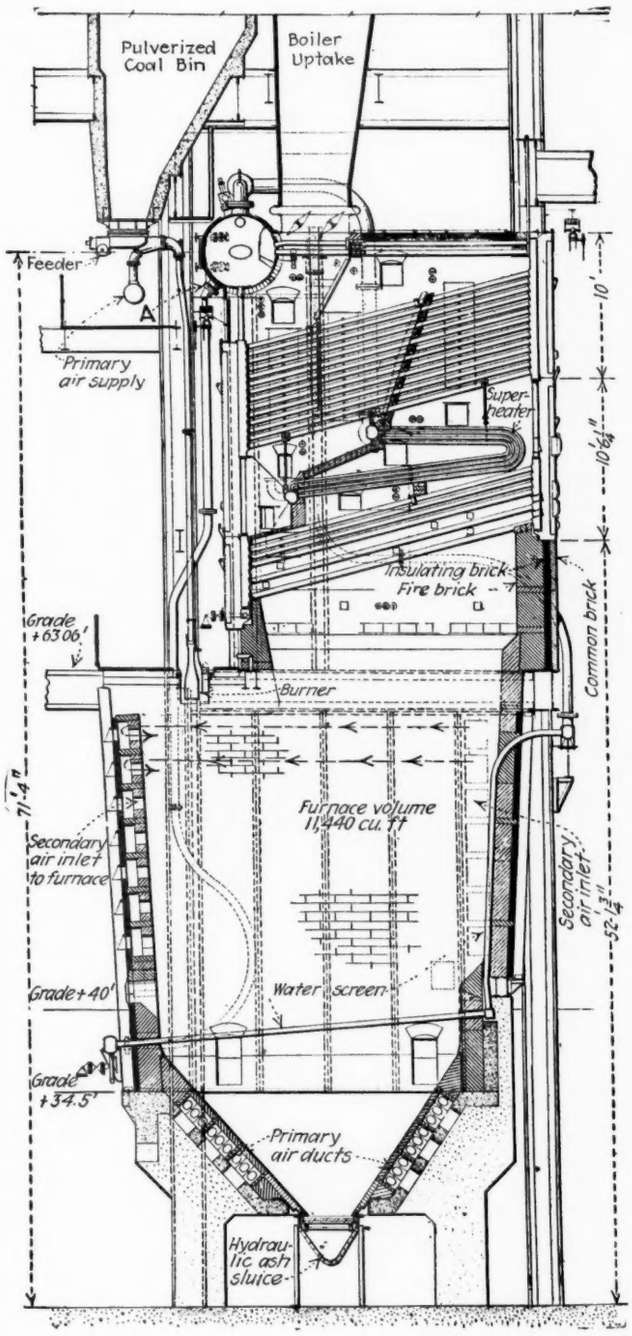


Fig. 13—Cross-section of boiler setting and furnace

space available for a low-temperature distillation plant if at some future time this should be considered advisable.

In addition to the facilities provided for handling the coal received by rail, a concrete dock built at the end of the station primarily for protection against scour of the river, is available for taking care of shipments

of any kind received in barges or transferring shipments from rail to barges.

From the inclined belt conveyors the coal is carried by bucket elevators to the top of the boiler house and delivered to a 30-in. belt conveyor which distributes it to the raw coal bunkers. The latter are of reinforced-concrete with a total capacity of 1,500 tons.

Referring to Fig. 3, it will be seen that the preparation plant is contained in the boiler-room structure. At the time the plant was designed, this was a departure from the usual practice of locating the preparation plant in a separate building. The section of the building housing the preparation plant is isolated from the driers and raw coal bunkers by a concrete floor, and from the rest of the boiler room by a solid brick and concrete wall with an exterior wall composed principally

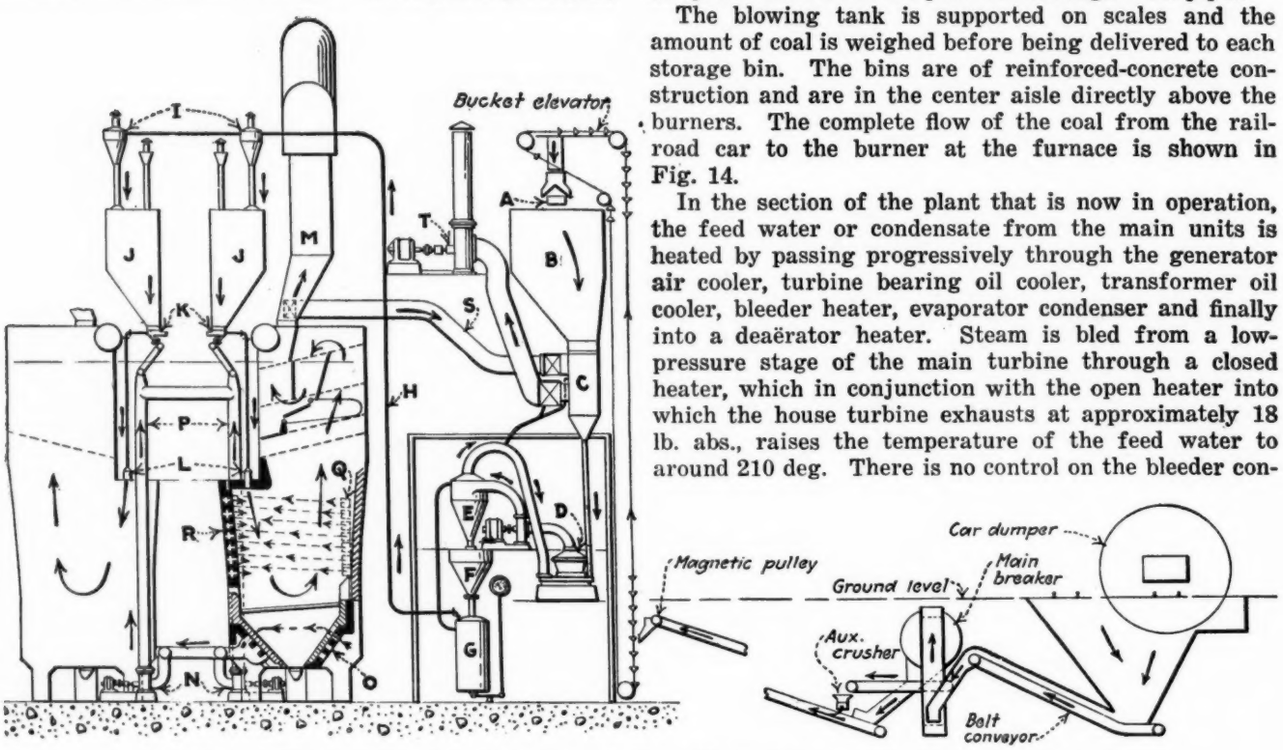


Fig. 14—Shows flow of coal from car dumper through preparation plant to furnace

A—Distributing conveyor over bunkers; *B*—Raw coal bunkers; *C*—Stationary waste-heat drier; *D*—Pulverizer; *E*—Cyclone collector; *F*—Collecting hopper between cyclone and blowing tank; *G*—Weighing and blowing tank; *H*—Pulverized-fuel transport line; *I*—Pulverized-fuel collector; *J*—Pulverized-fuel bin; *K*—Pulverized-fuel feeder; *L*—Pulverized-fuel burner; *M*—Boiler uptake; *N*—Primary air fan; *O*—Primary air inlet to ducts surrounding furnace bottoms; *P*—Primary air duct leading to header and feeders; *Q*—Secondary air inlet; *R*—Secondary air inlet to furnace; *S*—Hot gas connection to drier; *T*—Drier exhauster.

of thin glass windows. The space is further segregated into three distinct rooms, two of which contain four pulverizing mills with a capacity of five to six tons per hour, the largest then available, and the third room to house two mills of the same size and type. The initial installation was one 6-ton mill per boiler. Future installations will be one 15-ton mill for each two boilers. One of these mills, the first of this type and capacity, is now being installed. This will provide liberal mill capacity and, with liberal reserve when operating sixteen hours a day, will pulverize sufficient fuel for a twenty-four hour output of the station.

Interposed between the raw coal bunker and pulverizing mills are the waste-heat driers in which heat from the boiler exit gases is utilized for removing the moisture from the coal. The driers, through which the gases are drawn by 60,000 cu.ft. per min. motor-driven induced-draft fans, are designed with sufficient capacity to reduce the moisture in the coal from 12 to 5 per cent when 10 to 12 per cent of the boiler exit gas is being passed through it. Factors that influenced the selection of the waste-heat type of drier over the rotary type were the first cost, operating cost and reduction of space required.

From the driers the coal is fed by adjustable feeder into the pulverizing mills, where it can be ground so that approximately 65 per cent passes through a 200-mesh screen. The finished product is drawn from the mill by an exhaust fan and discharged to a cyclone, from which it drops to a collecting hopper and the air returns to the pulverizer. From the collecting hopper the coal drops by gravity to the blowing tank, from which it is transported to the bins above the boiler by compressed air at 50 lb. pressure through 4-in. pipes.

The blowing tank is supported on scales and the amount of coal is weighed before being delivered to each storage bin. The bins are of reinforced-concrete construction and are in the center aisle directly above the burners. The complete flow of the coal from the railroad car to the burner at the furnace is shown in Fig. 14.

In the section of the plant that is now in operation, the feed water or condensate from the main units is heated by passing progressively through the generator air cooler, turbine bearing oil cooler, transformer oil cooler, bleeder heater, evaporator condenser and finally into a deaërator heater. Steam is bled from a low-pressure stage of the main turbine through a closed heater, which in conjunction with the open heater into which the house turbine exhausts at approximately 18 lb. abs., raises the temperature of the feed water to around 210 deg. There is no control on the bleeder connection, the amount of steam bled varying with the load carried on the main unit.

Distilled water for makeup is supplied by a double-effect, low-pressure film-type evaporator. The supply is chemically treated Mississippi water. The use of treated water eliminates scale formation in the evaporator and makes reversing connections (for scale cracking) unnecessary.

The distilling capacity is 10,000 lb. per hour with steam at 2 lb. gage and 500,000 lb. per hour of circulating water (main water condensate) per hour entering the evaporator condenser at 150 deg. F. Each effect is vented independently to the evaporator condenser, from which both air and condensate are removed by a rotary air pump which delivers the distilled makeup to the open-type deaërating heater. This also receives the exhaust of the house turbine and the feed water leaving the cooling coil of the evaporator condenser.

A small coil heater inserted in the vapor connection between the second evaporator effect and the evaporator condenser preheats the evaporator feed.

The house turbines operate in parallel with house transformers off the main bus through a saturated core reactance and are given only such load as required with the various loads on the main unit to provide a good heat balance.

If it should be necessary at any time to operate the house turbines independently of the main turbines and still maintain a heat balance, the over-all efficiency of the station would be reduced about 3 per cent. Other conditions such as operating with the house turbine out of service would affect this efficiency less than one per cent.

Essential Auxiliaries Operated Off House Turbine Bus

Certain essential motor-driven auxiliaries necessary to keep the station in operation with an interruption to the main units are connected directly to the house-turbine bus and are normally operated off that bus. In case of interruption to the house turbine they can be fed from the house transformer bus through the current limiting reactors or short-circuiting switch. All the auxiliaries in the station are motor driven with the exception of one feed pump and one duplex turbine and motor-driven exciter.

Boiler-feed pump reserve capacity is liberally provided. There are four 4-in. 6-stage centrifugal pumps, three of which are motor driven and one turbine driven. The pumps are on the basement floor at the rear of the boilers directly below the deaërating heater from which the feed water is supplied. All pumps are automatically controlled.

All piping has been laid out with a view toward securing maximum simplicity with a minimum of duplication necessary for the continuity of operation. The high-pressure steam line is assembled with Sargol welded joints. The fittings and flanges are extra-heavy, conforming to the 800-lb. American hydraulic standard.

All connections to the boilers and other machines have been made as short and direct as possible, taking into consideration the expansion due to the high steam temperature. The main steam manifolds are located at the rear of the boilers about five feet above the floor at grade 40, to each of which four boilers are connected and a branch is taken off for the steam supply to one main unit and one house turbine. An additional connection is made to the manifold at the south end of the line for the steam supply to the turbine-driven feed pump and steam-driven exciter. The shut-off valves connecting pairs of boilers to the header and sectionalizing valves in the header are motor operated.

The main feed-water header is in the form of a loop with sectionalizing valve between parallel runs and between each two groups of four boilers. The piping is extra-heavy with rolled steel Vanstone joints and like the high-pressure steam line the flanges and fittings are extra-heavy, conforming to the 800-lb. American hydraulic standard.

Water for the several services in the station is drawn from the river and chemically treated by the cold process. The system is a duplicate of the process that has been used for several years at the Ashley Street Plant and is also a modification of the process used by the City of St. Louis for treating its domestic water supply.

The system embodies two treatments, primary and secondary. In the primary treatment the raw water is first passed to a weir box from which it is distributed by proportioning weirs to duplicate calcium hydrate and iron sulphate mixing tanks and dilution tanks.

In the dilution tanks the chemicals and the water to be treated are thoroughly mixed, then the whole is brought together in a riffle trough where the mixing is continued before passing to the precipitation tanks. The water thus treated is used for general services and is also pumped to the surge tanks, which supply the sealing water to the turbine glands and also serve to maintain a uniform head on the condensate header.

The secondary treatment consists in passing the water through barium-hydrate dilution tanks similar in detail to those employed for the primary process. This treatment is used only for further treating the boiler makeup before it is fed to the evaporators, as previously mentioned. The drinking water is also further treated, being first filtered, then chlorinated and finally cooled. More details of the water treatment will be presented in a subsequent article.

As will be seen from the elevation Fig. 3, the electrical bay of the station is between the turbine room and the river, with the step-up transformers directly above the screenhouse or river bay. All the units and feeders are connected to a 13,800-volt bus with sectionalized main ring, and in addition there is a reserve bus.

A vertical isolated phase arrangement for the buses and circuit breakers is used, employing a separate floor for each phase. The main and reserve buses of the same phase are on one floor, in separate rooms with an operating aisle between. The disconnecting switches are remote control manually operated and are interlocked mechanically with the oil circuit breaker.

Main Control Rooms Close Together

The 2,300-volt station service bus and circuit breakers are on the lower floor of the electrical bay, or at grade 20. The main generator and feeder control room is on a level with the lowest phase floor of the switch-house, this level being about twelve feet above the turbo-generator floor. Directly below, on a level with the turbine-room floor, is the auxiliary control room. From this room remote control of some of the auxiliaries is available such as the governor control of the house turbines and certain motor-driven auxiliaries. From this point all the motor-driven auxiliaries can be stopped but not started.

From the foregoing it will be noticed that the two main control rooms of the station have been brought close together. This tends to reduce the number of employees and at the same time increase the dependability of the plant.

Current is transmitted at 13,800 and 33,000 volts through step-up transformers to the several substations of the system. The station is also connected with the Ashley Street Plant through three 33,000-volt direct tie lines.

In the second section of the plant, now under construction, several changes will be made in the heat cycle. In place of the house turbine two additional stage heaters will be used. Steam for feed heating will be bled from the tenth, twelfth and fourteenth stages of the seventeen-stage machine, the final temperature of the feed water being controlled by regulating the steam to the No. 3 heater. A departure will also be made in the deaërating heater, which will be of the closed type.

Although house turbines will not be installed in the future extensions to the station, if the present plans are carried out, current from the house turbine in the first section will be available for driving the auxiliaries in emergencies. This will be accomplished by extending the house turbine bus and connecting it to the house service bus in each section.

In this extension there will be a 30,000-kw. General Electric 17-stage machine and a 35,000-kw. Westinghouse unit. The latter is equipped with multi-exhaust type blading. Each will be connected for three-stage bleeding. Apart from the changes just mentioned, the design of the third unit and the equipment that will be installed will be essentially a duplicate of the two units in the first section.

Engineers' Report of Operation Since the Station Has Gone into Service

A summary prepared by the engineers and covering the period of operation of the plant up to the time of preparing this article, follows:

This station was put into service on Oct. 15, 1923, or about thirteen months after the first pile was driven, because of the urgent demand for additional power.

Since then one turbo-generator has been continuously in commercial service and the other intermittently from Nov. 30 to Feb. 20, and continuously since the latter date.

Seven boilers were put into steaming service on various dates from Oct. 2 to Jan. 10, and the eighth boiler on Feb. 15, and the various elements of coal handling and coal preparation as needed in advance of boilers and furnaces.

The total station economy from coal as received on car dump has been as follows:

	B.t.u. per Kw.-Hr. Gross	Net	Maximum Load, Kw.	Capacity Factor	Net Output Kw.-Hr.
January, (31 days).....	17,922	19,310	40,000	30.3	13,503,200
February, (29 days)....	17,579	18,649	45,000	36.3	15,175,900
March, (15 days).....	17,339	18,360	45,000	47.0	10,145,400

The foregoing is exclusive of economizers or air preheaters, none having been installed, as the station was designed to burn low-grade coal averaging $2.50 per ton. The station has not yet reached its permanent operating load, as indicated by the maximum load and the capacity factor and output given.

No official or acceptance tests on principal equipment have so far been made except on the No. 1 turbo-generator, with the following results:

Water Rate, Pounds per Kw.-Hr. Corrected for 300 Lb. Gage and 250 Deg. F. Superheat at Throttle.

Load, Kw.	Vacuum ½ in. Abs.	Vacuum 1½ In. Abs.	Vacuum 1 In. Abs.
30,000	9.42	9.45	9.56
23,000	9.57	9.64	9.80
15,000	9.97	10.20	10.41
10,000	10.54	10.90	11.3

The temperature of the flue gases to driers has been varied from 200 to 380 deg. F. for trial and observation, but the average has been increased from time to time, and was 300 deg. F. during the first 15 days of March. The coal used is of a character that catches fire occasionally in ordinary raw-coal bunkers. Since the first drier was put into service, coal has caught fire twice in drier No. 4 to an extent requiring repairs—the first at a cost of about $1,400, and the second, about $100. There were no other fires that required repairs. These two fires were the result of shutting down the driers before all the coal had passed through them. By making it a practice to shut down the driers sufficiently in advance of the mills to prevent lodgment of warm coal in drier, any subsequent fire from spontaneous combustion is thus prevented. There have been twelve smaller so-called fires requiring no repairs and extinguished readily with steam permanently piped with relief for that purpose to the driers, most of them occurring when the driers were out of service and full of warm coal. Such other hot spots as were found occasionally in driers or hoppers below were not sufficient to warrant turning on the steam.

Tests have been and are still being conducted at different flue-gas temperatures to determine the particular gas temperatures for coals of different moisture content which will produce the best operating results. The maximum gas temperatures entering the driers are sufficiently lower to insure no fires directly from hot gases. All fires that have occurred were due to spontaneous combustion of warm coal left in driers or hoppers subject to air infiltration.

The installation of gates between bunkers and driers, the replacement of butterfly dampers with sliding gas-tight dampers, and some improvements inside the driers and ducts will make it possible to reduce greatly the number of fires and to isolate and extinguish fires more quickly should any occur.

There have been six fires in about six months in the eight pulverizing coal bins, due to spontaneous combustion at times of low barometric pressure, and they were located directly under the open vent pipes. They were easily put out by closing the bins and allowing the CO_2 gas generated in the bin to smother the fire. The vent pipes have since been equipped with light-weight check valves which relieve the bin of excess pressure and at the same time prevent the entrance of air.

The only trouble experienced with the powdered-coal transport system was due to excessive moisture permitted to remain in the coal. This occurred during extreme cold weather for St. Louis, and when the driers were not in service. In this experience it was found that it is important to dry the particular coal then used to at least 5 or 6 per cent moisture.

One of the cyclone separators in the pulverizing room and one on the boiler-room roof and one weighing and blowing tank have been covered with two-inch hair felt to avoid condensation as an experiment, but as a result it seems unnecessary to provide covering on this equipment.

The station records indicate that furnace operation has been adjusted to give 15 to 16 per cent CO_2 without slagging in the furnace with exit-gas temperature of 450 deg. leaving the boiler at 190 per cent rating. No repairs have been found necessary on the boiler furnaces or water screen, and the last inspections indicate no distress in any part.

After about five months of preliminary testing, operating and research, designs have been approved and contracts placed for unit No. 3 fuel preparation including driers, transport and combustion equipment to duplicate substantially that on units 1 and 2, on which the experience obtained has been embodied, as previously stated.

The design and construction of the Cahokia Station was carried out by McClellan & Junkersfeld, Inc., engineers and constructors, New York and St. Louis, under authorizations of Louis H. Egan, president of Union Electric Light & Power Co., St. Louis, Mo., and with the collaboration of his technical assistant, H. W. Eales, chief electrical engineer, and E. H. Tenney, chief engineer of power plants.

DATA ON PRINCIPAL EQUIPMENT IN CAHOKIA STATION OF UNION ELECTRIC LIGHT & POWER CO.

GENERAL

Location of plant	East bank of Mississippi River near East St. Louis
Character of service	Light and power
Capacity present building, kw	60,000
Capacity under construction, kw	65,000
Capacity ultimate, kw	300,000 or more

	Width	Length (Present)	Length (Ultimate)
Boiler room, ft	106	171	630
Turbine room, ft	58	193	672
Electrical bay, ft	36	171	630
River bay	21	171	630

Type of construction	Brick curtain wall on steel frame
Foundations	Concrete mat on concrete piles
Floors	Reinforced concrete
Type of piles	Precast concrete bearing piles; precast concrete sheet piles; cast-in-place concrete piles
Manufacturer	Raymond Concrete Pile Co.
Waterproofing of substructure	Gardiner & Lewis, Inc.
Engineers and constructors	McClellan & Junkersfeld, Inc. New York City

IMPORTANT RATIOS

Cubic feet of building to installed kw	(present) 57.3 to 1; (ultimate) 43.3 to 1
Boiler-heating surface to installed kw	2.4 to 1
Furnace volume to installed kw	1.5 to 1
Furnace volume to boiler surface (including water screens)	0.615 to 1
Condensing surface to installed kw	1.75 to 1
Circulating water, in gal. per min., to installed kw	1.80 to 1
Installed kw. capacity to boiler-feed pump capacity in gal. per min	20 to 1

BOILER, SUPERHEATERS AND AUXILIARIES

Manufacturer	Babcock & Wilcox Co.
Type of boiler	Horizontal cross-drum, sectional water-tube
Number installed (present)	8
Steam-making surface per boiler, sq.ft	18,010
Furnace volume, cu.ft	11,440
Sq.ft. of steam-making surface per cu.ft. of furnace volume	1.57
Arrangement of tubes	20 tubes high, 38 wide
Size of tubes	4 in. dia. by 20 ft.
Size of drum	60 in. dia. by 33 ft. 6 in.
Water screen	Combustion Engineering Corp.
Effective surface, sq.ft	580
Size of tubes, in	4
Boiler pressure, lb. gage	350
Type of superheater	Convection
Manufacturer	Babcock & Wilcox Co.
Location of superheater	Above sixth row of boiler tubes
Superheating surface per boiler, sq.ft	4,070
Size of tubes	2 in. No. 10 gage
Ratio superheating to steam-making surface	1 to 4.42
Soot blowers (Diamond) 18 elements	Diamond Power Specialty Corp.
Feed-water regulators (Copes) 2 per boiler	Northern Equipment Co.

FUEL

Kind	Belleville
Heat value, B.t.u. per lb. as received	9,947

FURNACES

Type	Air-cooled side wall and ash hopper, water-screen-cooled rear wall and bottom
Firebrick	Laclede-Christy Clay Products Co.; Evens-Howard Fire Brick Co.
Refractory tile	Walsh Fire Clay Products Co.
Insulating brick (Sil-o-cel)	Celite Products Co.
Suspended arches	Four H. M. Detrick Co., four Liptak Fire Brick Arch Co.
Furnace casing	Sheet steel
Ash gates, two per boiler	Allen-Sherman-Hoff Co.
Furnace volume, cu.ft	11,440
Ratio furnace volume to boiler surface (including water screens)	0.615 to 1

RAW COAL HANDLING EQUIPMENT

Track scale	Buffalo Scale Co.
Rotary car dumper, 90-ton capacity	Link Belt Co.
Conveyors, apron and belt, 300-ton capacity	Link Belt Co.
Belting for conveyor (6-ply rubber)	U. S. Rubber Co.
Coal breaker, Bradford, 400-ton capacity	Pennsylvania Crusher Co.
Crusher, swing-ring, 60-ton capacity	American Pulverizer Co.
Magnetic separator, two, 24x36 in	Dings Magnetic Separator Co.,
Storing and reclaiming:	
One locomotive crane	Brown Hoisting Machy. Co.
One locomotive crane	American Hoist & Derrick Co.
Industrial locomotive	American Locomotive Works

PULVERIZED COAL HANDLING EQUIPMENT

Platform scales, 4.5 tons capacity	Howe Scale Co.
Coal transport, compressed air, 94 tons per hr.	Fuller-Lehigh Co.
Storage, concrete bins, 500 tons capacity.	

DRYING, PULVERIZING AND COMBUSTION EQUIPMENT

Driers, ten Lopulco waste-heat	Combustion Engineering Corp.
Capacity, tons per hour, 12 to 5 per cent moisture	6.5
Fans, two, induced draft for drier	B. F. Sturtevant Co.
Capacity cu. ft. per min	60,000
Drive, 125-h.p. 2,300-volt, Wagner 3-phase motor.	
Pulverizers, eight, six-roll "Raymond Bros."	Combustion Eng. Corp.
Capacity, each, tons per hour	6
Drive, direct connected 100-h.p. 2,300-volt Wagner ind. motor.	
Pulverizer one, six-roll "Raymond Bros"	Combustion Eng. Corp.
Capacity tons per hour	15
Drive—belted 200-h.p. G. E. Co. ind. motor	
Feeders (Lopulco)	Combustion Eng. Corp.
Number, per boiler	10
Drive (ten feeders)	15-h.p. variable-speed Westinghouse d.c. motors.
Fans, primary air	B. F. Sturtevant Co.
Number	4
Capacity each cu.ft. per min. 15 m. static, press	20,000
Drive, 100-h.p. 1,200-r.p.m., 2,300-volt Wagner ind. motor Combustion control, two boilers	Bailey Meter Co.

ASH-HANDLING EQUIPMENT

Manufacturer	Allen-Sherman-Hoff Co.
Type	Hydraulic sluicing delivering to sump.
Dredge pump, two 6-in. centrifugal	Morris Machine Works
Drive, 75-h.p. 2,300 volt Wagner Slip Ring ind. motor.	

STACKS

Builder	Wiederholdt Construction Co.
Type	Tile concrete
Inside diameter at top, ft	19
Height above burners, ft	325
How supported	Building steel

FEED PUMPS AND AUXILIARIES

Manufacturer	Allis-Chalmers Mfg. Co.
Number	4
Type and size	4-in., 6-stage centrifugal
Speed r.p.m.	1,76
Capacity, gal. per min. at 425 lb. pressure	750
Drive:	
3 pumps, each, 300-hp. 2,300-volt, General Electric Co. slip-ring ind. motor, 1 pump, 300-hp. turbine	Terry Steam Turbine Co.
Feed-pump control, motor-driven pumps	Ruggles-Klingemann Co.
Turbine-driven pumps	Fisher Governor Co.
Feed-water heaters, 2 closed type	Alberger Pump & Condenser Co.
Evaporators (Lillie) (feed-water makeup)	Sugar Apparatus Mfg. Co.
Type (film)	Low-pressure, two effect
Capacity, lb. per hour	10,000
Deaerators	H. S. B. W. Cochrane Corp.
Type	Open heater, reboiler type
Capacity, lb. per hour	720,000

MAIN GENERATING UNITS

Manufacturer	General Electric Co.	Westinghouse Elec. & Mfg. Co.
Type	Curtis 17-stage	Semi double-flow
Number installed	One	One
Rating kw. 85 per cent power factor	30,000	30,000
Ventilating air, cu.ft. per min. 104 deg. F	80,000	84,000
Type of generator each unit 3-phase, 60-cycle 13,800-volt		
Speed of units, r.p.m.		1,800
Steam condition turbine throttle		300 lb. 690 deg. F

CONDENSERS AND AUXILIARIES

Manufacturer	Worthington Pump & Mch.Corp
Number	2
Type	Two pass, surface
Tube surface, each, sq.ft	53,000
Tubes, diameter, in	1
Material, admiralty metal	18 bwg.
Manufacturer	Wheeler Cond. & Eng. Co.
	Scovill Mfg. Co.
Circulating pump, 30-in. centrifugal	Worthington Pump&Mch.Corp.
Number each condenser	2
Capacity, each gal. per min	33,000
Drive, 250-hp. 2,300 volt, G. E. Co. slip-ring ind. motor	
Condensate pumps, each condenser two 6-in.	Worthington Pump &Mch.Corp.
Capacity, each, gal. per min. 225 ft. head	800
Drive	75-hp. 2,300-volt Wagner slip-ring ind. motor
Vacuum pump, each condenser, one	Worthington Pump& Mch.Corp.
Type, 33x24 in. Laidlaw-Dunn-Gordon, dry vacuum	
Drive	Silent chain to 50-hp. 440-volt Wagner slip-ring ind. motor
Sluice gates, eleven, circulating-water inlet	Coffin Valve Co.
Butterfly valve, one, circulating-water inlet	Coffin Valve Co.
Traveling water screens, circulating intake	Link Belt Co.
Drive	5 hp. 1,200 r.p.m. Wagner ind. motor through speed reducer
Speed reducer	W. A. Jones Fdry. & Mach. Co.

HOUSE TURBINES

Manufacturer	Westinghouse Elec. & Mfg. Co.
Type	Horizontal non-condensing
Number	2
Rating, kw., 80 per cent power factor	2,000
Type of generator	3-phase, 60-cycle 2,300-volt
Speed of units, r.p.m.	3,600
Steam conditions at throttle	300 lb. 690 deg. F.
Exhaust pressure, lb. absolute	18
Ventilating air, cu.ft. per min. 104 deg.	8,000
Service	Station auxiliaries

DATA ON PRINCIPAL EQIPMENT IN CAHOKIA STATION OF UNION ELECTRIC LIGHT & POWER CO. (Concluded)

GENERATOR AIR-COOLING SYSTEM

Type	Closed syst. with surface coolers
Coolers, two, surface (condensate used as cooling medium)	The Griscom-Russell Co.
Heat exchangers, two, spiral-flow (for subcooling condensate, using circulating water as cooling medium)	Whitlock Coil Pipe Co.

FIRE SUPPRESSION SYSTEM

Primary	Receivers of CO_2 gas at 200 lb. pressure discharging to closed ventilating systems
Secondary	Water coils in end bells of generators.

MOTORS

104 induction motors up to 150 hp	Wagner Electric & Mfg. Co.
15 induction motors above 150 hp	General Electric Co.
14 direct-current motors	Westinghouse Elec. & Mfg. Co

PIPING, VALVES AND COVERING

High-pressure steam, piping and fittings	Midwest Piping & Supply Co.
Low pressure steam piping and fittings	Steere Engineering Co.
Circulating-water piping	Joubert & Goulin Mch.&Fdy.Co
Non-return and high-pres. steam globe valves	Edward Valve & Mfg. Co.
High-pressure steam gate valve	Crane Co.
Motor operating equipment for high pres. gate valves	Payne Dean, Ltd.
Boiler-feed gate and check valves	Chapman Valve Mfg.
Boiler-feed globe valves	Lunkenheimer Co.
Low-pressure steam and water valves	Nelson Mfg. Co.
Hydraulically operated gate valves circ. lines	Kennedy Valve Mfg. Co.
Atmospheric relief valves	Atwood & Morrill
Blowoff valves, "Yarway" seatless Yarnall-Waring Co. in series with Lunkenheimer gate valves.	
High-pressure steam joints, type	Sargol, 800 lb. hdy. std
High-pressure, boiler feed and low pressure steam joint, type	Vanstone
Pipe coverings high-temp. and 85 per cent magnesia	Philip Carey Co.

SPECIAL CENTRIFUGAL PUMPS

Raw-water pumps, five 6-in. 2-stage	Worthington Pump & Mchy. Corp.
Capacity, gal. per min. at 200 ft. head	500
Drive, 50-hp 440-volt, 3-phase	Wagner induction motor
Sludge pumps, two 4-in. single stage	Worthington Pump&Mch.Corp.
Capacity, gal. per min. at 75 ft. head	350
Drive, 15-hp. 440-volt 3-phase	Wagner induction motor
Makeup water pump, two 4-in. single stage	Worthingon Pump &Mch.Corp.
Capacity, gal. per min. at 65 ft. head	500
Drive, 20-hp. 440-volt 3-phase Wagner induction motor	
Sump pumps, 3-in. single-stage	Yoemans Bros.
Capacity, gal. per min. at 75 ft. head	500
Drive, 20-hp, 440-volt 3-phase Wagner induction motor	
Fire pump, one 6-in. two-stage	Dayton Dowd Co.
Capacity, gal. per min. at 200 ft. head	750
Drive, 75-hp. 2,300-volt 3-phase Wagner induction motors	
Vacuum pumps, heating system, 2-in.	Nash Engineering Co.
Drive, 2-hp. 440-volt, 3-phase Wagner induction motor	
Circulating pumps for transformer oil	Worthington Pump & Mch.Corp
Seven 2-in. two stage	
Capacity, gal. per min. at 80-ft. head	110
Drive 5-hp. 440-volt, 3-phase Wagner induction motor	
Priming vacuum pump, two, (Hytor)	Nash Engineering Co
Drive, 7½-hp. 440-volt, 3-phase Wagner induction motor	

WATER SUPPLY AND TREATMENT

Source of supply	Mississippi river
Impurities	Scale forming salts
Primary treatment	Calcium hydrate and iron sulph.
Manufacturer	Graver Corporation
Type of equipment	Cold process
Capacity, gal. per min	600
Service	Cooling bearings and surface water
Secondary treatment	Barium hydrate
Manufacturer	Graver Corp.
Type	Cold process
Capacity gal per min	600
Service	Evaporator raw water and emergency makeup to boilers
Traveling weigh larry for chemicals	Strait Scale Co.
Drinking water, source of supply	After primary treatment
Treatment	Filtered, chlorinated and cooled
Capacity, gal. per min. at 50 deg. F	20
Refrigerating system for cooling (Ammonia)	R. H. Tart Sons, Inc.
Filters	The New York Continental Jewell Filtration Co.
Type	Sand and bone black

INDICATING AND RECORDING INSTRUMENTS

Indicating and recording resistance thermometers	Wilson Maculen Co.
Recording thermometers and pressure gages	Foxboro Co.
Steam-flow meters	General Electric Co.
Recording flow meter for feed water	Simplex Valve & Meter Co.
Recording meter, steam and gas flow, flue-gas temperature	Bailey Meter Co.
Indicating pressure and vacuum gages	Crosby Steam Gage & Valve Co. Schaeffer & Budenberg Mfg. Co., C. J. Tagliabue Mfg. Co., Manning, Maxwell & Moore, Inc.(Ashcroft)AshtonValveCo.
Indicating dial thermometers	C. J. Tagliabue Mfg. Co.
Mercurial industrial thermometer	Taylor Instrument Co's.

MISCELLANEOUS EQUIPMENT

Air compressors, 3	Sullivan Machinery Co.
After coolers	Whitlock Coil Pipe Co.
Traveling crane (turbine room)	Niles-Bement-Pond Co.
Test tanks	Hamler Boiler & Tank Co.
Test scales	Strait Scale Co.
Oil purifiers—centrifugal	De Laval Separator Co.
Oil circulating pumps	American Steam Pump Co.
Oil coolers—for transformers	Whitlock Coil Pipe Co.
for G. E. Co. turbine	Andale Engineering Co.
for W. E. Mfg. Co. turbine	The Griscom-Russell Co.
Ventilating fans	American Blower Co.
Vacuum cleaning system	Allen & Billmeyer Co.
Elevators	Otis Elevator Co.

Other electrical equipment furnished by General Electric Co., Westinghouse Elec. & Mfg. Co., Electric Power Equipment Corp., Metropolitan Device Corp., Electric Storage Battery Co., Standard Underground Cable Co., Simplex Wire & Cable Co., Safety Insulated Wire & Cable Co., American Steel & Wire Co., United States Rubber Co., T. Thomas & Sons, General Device & Fitting Co., Western Electric Co., Manhattan Electrical Supply Co., Johns-Manville, Inc., Weston Electrical Instrument Co., Gamewell Fire Alarm Tel. Co., Frank Adams Electric Co., The Holophane Co., The National Co., Benjamin Electric Mfg. Co., All Steel Equipment Co., Columbia Metal Box Co., American Copper Products Co., Cutler-Hammer Co., Crouse Hinds Co.

Lubrication of Refrigeration Compressors

BY ALLEN F. BREWER

While anhydrous ammonia is perhaps the most generally used refrigerant today, there are a number of other chemicals, such as carbon dioxide, sulphur dioxide, propane, ethyl chloride and methyl chloride, which can be more or less readily employed for the purpose of refrigeration, with certain decided advantages. In fact, from the viewpoint of safety in handling many of these are often regarded as preferable to ammonia. Therefore, the lubrication requirements of their respective machinery will be of interest, since these involve certain marked differences from the lubrication of the ammonia compressor.

CARBON DIOXIDE AS A REFRIGERANT

Carbon dioxide (CO_2) or, as it is often termed, carbonic anhydride, is perhaps more like ammonia in its application to refrigeration purposes than any of the other lesser refrigerants. In fact, the only difference in machine requirements is that more rigid construction of the compressor is necessary, for the pressures (250 to 1,000 lb. per sq.in.) are considerably greater. The natural advantages of carbon dioxide over ammonia as a refrigerant, however, outweigh this possible disadvantage, in the opinion of many authorities, for it is non-explosive, non-poisonous, non-combustible, odorless, cheaper, neutral in chemical reaction and an effective fire extinguisher. As a result leaks in a carbon-dioxide system may be often disregarded and never feared, even though they may possibly occur more frequently on account of the higher operating pressures involved.

An added advantage exists by virtue of the fact that straight mineral oils have practically no affinity for carbon dioxide. As a consequence the possibility of the compressor oil being carried over into the refrigerating system by the compressed gas is negligible. In fact, this could occur only in event of the oils becoming vaporized, and the compressor discharge temperatures will never be high enough to promote any appreciable vaporization of the lubricating oil. Suitable oil traps should be installed in the compressor discharge line to catch any oil that might pass over with the refrigerant in the form of spray.

The most suitable lubricant for a CO_2 compressor is a straight mineral product of fairly low viscosity. It should possess two essential characteristics, a low pour test and a flash point sufficiently higher than the customary discharge temperature to insure that it will not be subjected to vaporization or distillation.

Adequate sealing of the stuffing boxes in a CO_2 compressor, whether vertical or horizontal, is a decidedly important matter. In general stuffing boxes are sealed, piston rods lubricated, and leakage of gas prevented by force-feed lubrication, the lubricant being fed through an oil lantern or hollow space located between two separate sets of rod packing.

Sulphur Dioxide Used in Small Systems

Sulphur dioxide is another chemical that is somewhat used in small refrigerating systems. It is not as satisfactory as carbon dioxide owing to its tending to show an acid reaction when in solution with water and the fact that it is a fairly active poison in gaseous form. It is not, however, regarded as dangerous to use on this account, any more than is ammonia. The outstanding feature in the application of sulphur dioxide to refrigeration purposes is the low pressures in the system, but the fact that it requires a relatively high compressor volume has largely interfered with its extended use.

Lubrication of sulphur-dioxide machinery involves certain difficulties due to the inherent nature of the refrigerant itself. In the first place the lubricant must be absolutely water-free, otherwise the gas will tend to react with this water to form sulphuric acid, which would prove very destructive to the metals from which the compressor is built. The effect that sulphur dioxide may have upon the lubricant must also be considered. Mineral oils as usually obtained have not proved to be absolutely satisfactory lubricants owing to the fact that sulphur dioxide tends to manifest an affinity for certain of the hydrocarbon constituents. As a result many mineral oils will be altered both chemically and from a lubricating point of view, to a certain extent. Some authorities consider it quite possible, however, to take mineral oils of somewhat higher viscosity and so refine them by either filtration or suitable chemical treatment, that their hydrocarbon components which may be affected by the sulphur dioxide, will be removed. The resultant product is then claimed to be an efficient and dependable lubricant.

In ordinary operation, however, sulphur-dioxide refrigerating compressors are usually lubricated with chemically pure glycerin or glycol. The latter is frequently spoken of as being perhaps the most effective sulphur dioxide compressor lubricant on account of its relatively low pour test, especially when it has been compounded with deflocculated graphite.

Ethyl and Methyl Chlorides

Ethyl and methyl chlorides can be discussed together from the viewpoint of the lubrication requirements of their systems of refrigeration, because of their similarity. In general they will be found to show no reaction with air or water, nor are they poisonous or objectionable as to odor. In addition, they are chemically neutral and only slightly inflammable. They have, however, relatively low specific heats, and larger volumes of each are required for the development of a given amount of refrigeration as compared to the volume of ammonia. So the rotary type of compressor is preferred by many owing to its ability to handle effectively large volumes at low pressures. On account of the low pressures involved, the loss of lubricant via stuffing boxes, etc., is generally smaller than where high-pressure refrigerants are used.

Lubrication of compressors wherein these refrigerants are to be used must be considered from the viewpoint of the effect the refrigerant will have upon the lubricant. Mineral oils are generally regarded as being unsuited, owing to the fact that certain hydrocarbons are more or less soluble in these chlorides. Chemically pure glycerin is, therefore, commonly used as the lubricant. The glycerin must be free from water or other foreign matter, otherwise poor lubrication and a certain amount of gumming will take place. In fact, the builders of compressors for such service recommend only the use of chemically pure glycerin at all times. In using or storing glycerin it must be remembered that it has an affinity for water and tends to absorb moisture from the air when exposed. It should, therefore, be kept as nearly air-tight as possible at all times.

The cycle that glycerin follows in performing its lubricating functions in a rotary compressor is of interest. In general, the start of the cycle is its delivery to each end of the compressor via suitable lubricant connections and through ducts or channels to the bearings, passing along these to the interior of the compressor. It is then discharged to the condenser and separator along with the compressed refrigerant. Here separation of the two is effected by virtue of the lubricant being the heavier, the refrigerant passing on to serve its intended purpose, the lubricant being forced back to the compressor for re-usage. This is a continuous cycle during operation. Generally, a suitable strainer and sight-feed device is installed to insure the maintenance of effective and sufficient lubrication at all times.

Propane and Other Hydrocarbons

While the idea of using certain hydrocarbon gases such as propane, ethane and butane for the purpose of refrigeration is not new, the actual application on a commercial scale is relatively recent. Propane has taken precedence over the others and is today a feature in certain household and commercial refrigerating systems. Propane is of advantage in that comparatively low temperatures are attained by its usage; it also requires lower pressures for compression. Furthermore, it is non-corrosive, involves no acidic reaction with water, is relatively stable under usual refrigerating conditions, is not dangerous except in event of sufficient concentration to exclude oxygen and is adapted to usage in a standard type of ammonia compressor if desired. On the other hand, as a hydrocarbon it is inflammable, therefore open flames should never be allowed in its vicinity.

Satisfactory lubrication of refrigeration machinery wherein propane is employed is as yet in more or less of a development stage. As in the case of ethyl chloride a lubricant must be selected no part of which will be soluble to any extent in the refrigerant, otherwise its lubricating ability will be impaired more or less seriously. Mineral lubricating oils are, therefore, not regarded as suitable by many authorities. Experiments have been carried out using castor oil, lard oil and certain glycerides. As far as is known, these products or certain of their compounds have indicated their suitability where normal operating conditions exist.

Present-Day Diesel Engines—Application of the Two-Stroke-Cycle Principle*

By PROFESSOR NAGEL

THE controversy that existed between advocates of the four-stroke-cycle and the two-stroke-cycle gas engine threatens to duplicate itself with respect to the Diesel engine, and old prejudices arising therefrom have been detrimental to new development. It is important to note that the two-stroke-cycle Diesel engine has come rapidly into favor and that this type will doubtless be further perfected in the future.

The principal problem presented by the two-stroke-cycle gas engine—namely, the distinct separation of the scavenging process from the suction of a new charge of mixture so as to avoid the loss of unburned gas with the exhaust—is not present in the Diesel engine.

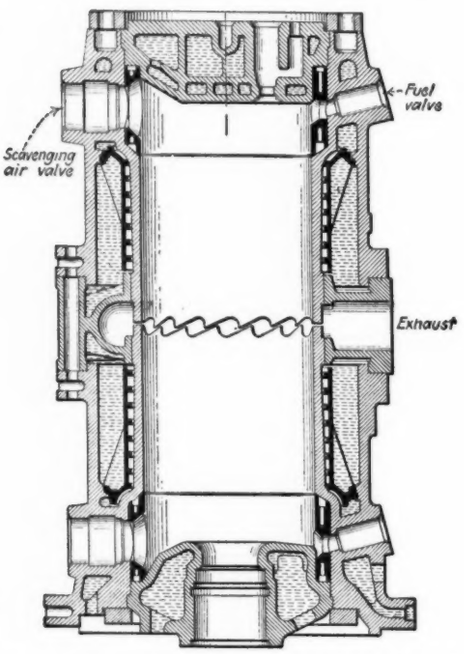


Fig. 1—Cross-section of successful cylinder

The problem in the latter revolves itself into minimizing the amount of air required for scavenging.

There are three important reasons for the existence of two-stroke-cycle Diesel engines: In the first place from 75 to 90 per cent more horsepower can be obtained for a given piston stroke than in the four-stroke-cycle type. These percentages are net, full provision having been made for the power required to compress the scavenging air and the power reduction by the lower engine speed. In view of this fact there is a natural endeavor to make the cylinders as large as possible.

A decisive advantage of the two-stroke-cycle principle is the elimination of exhaust valves, as their function is taken over by the piston which uncovers slotted ports in the cylinder. However, the scavenging air is not always admitted by the main piston in this manner in all two-stroke-cycle engines; it frequently enters through special valves. Hence there are two types. In the former the greater simplicity prevails, as the only valves needed are the air-suction valve and the fuel-injection valve. There is a natural incentive to build two-stroke-cycle engines of this type in small and medium sizes because of the low manufacturing cost. These engines operate with low piston pressure and with a low thermal efficiency.

The ideal striven for by the builders of large two-stroke-cycle engines in competition with four-stroke-cycle engines is to obtain the same high power output per cylinder with equal thermal efficiency and dependability and to have the additional advantage of greater simplicity.

This endeavor began with building engines that were scavenged through valves and has finally led to the slotted-port scavenged engine, admittedly the most efficient of the two-stroke-cycle type. As early as 1911 the Junkers port-scavenged engine was placed on the market, but it did not meet with much success in Germany. It was later transferred to England and resulted in the production of the Doxford engine. Junkers is now planning to build small high-speed units of this type in Germany which will doubtless find a market in the automobile and airplane industries.

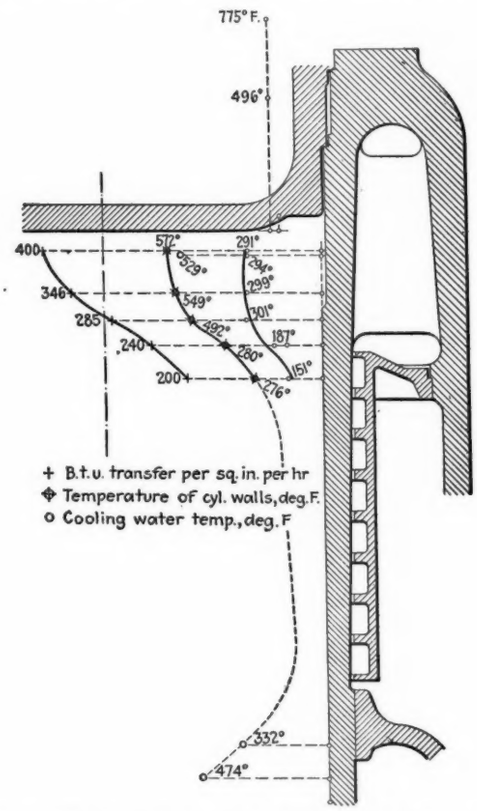


Fig. 2—Temperatures and heat transfer in cylinder

*Extract of paper read before the Vereines Deutscher Ingenieure, June 20, 1923, at Berlin.

Attempts have been made in Germany to build double-acting marine Diesel engines. In 1910 the M. A. N. at Nürnberg and the Germania Works at Kiel designed engines of 12,000 hp. rating for the navy. The former engine had scavenging valves, whereas the Germania engine was of the slotted port scavenging type. The Nürnberg engine was intended to deliver 12,000 hp. power, was built and tested during the period from Jan. 4 to April 5, 1917, making a total of 2,100,000 revolutions, and was operated continuously for five days with a variable load from 10,800 to 12,000 hp. At the conclusion further tests were made on one cylinder to determine the ultimate overload capacity. This cylinder developed 3,573 hp. at 145 r.p.m. with a mean indicated effective pressure of 147 lb. The mechanical efficiency, including the operation of the electrically driven auxiliary equipment, reached 90 per cent. The fuel used was anthracite tar oil with an ignition oil. The tests showed a gradual increase in load from noon until 5 p.m. from 2,472 to 3,218 hp. The entire engine would at this rate have developed a total of 17,150 hp., which represents 143 per cent of the expected rating.

This engine may also be remembered in connection with the fatal scavenging air explosion in January, 1912, and the increasing and finally successful efforts to overcome the many difficulties experienced with the materials used in modern Diesel-engine construction. The cylinder bore was 33.46 in. and the stroke 41.34 in. To realize fully the daring and courage required to attempt to obtain such a large performance from a single engine cylinder, it must be remembered that the largest six-cylinder Diesel engine at that time was rated at only 1,000 hp. Many years of the hardest effort were necessary to overcome the many difficulties that presented themselves to the designer. In the first designs the cylinder lining was made of a single casting and the cylinder head contained the fuel-injection and the scavenging-air valves, which were placed in pockets cast in the head. This construction was a failure, as it caused the walls of the exhaust passages to crack and breaks developed in the cylinder head. These troubles led to the redesign of the entire cylinder, which is shown in Fig. 1.

The cylinder consists of an upper and a lower section, held together by a ring-shaped piece in the annular exhaust passage. The exhaust slots were formed by the saw-tooth shape of the adjoining ends of the two cylinder liners, which were not in contact with each other. This allowed for the free expansion of the liners, so that no injurious stresses were developed and transmitted by them to the frame.

Cooling of the cylinder liners was augmented by a surrounding casting of special design provided with helical passages that caused the cooling water to circulate helically across the surface at a high velocity.

The fuel-injection and scavenging-air valves were contained in housings that traversed the cooling-water space in the heads. The upper cylinder head also contained a starting valve and a safety valve, whereas the crank-end head contained only a safety valve. Each half of the cylinder had four scavenging-air valves and two fuel-injection valves. The latter were on the cross axis of the cylinder in the plane of the crank motion. This location was the result of extensive experiments and was intended to secure the better utilization of the compressed air by tangential injection and at the same time to promote more efficient combustion.

The fact that the high temperatures frequently caused the walls of the valve housings where they touch the cylinder walls to corrode resulted in the insertion of steel rings to protect these parts from the hot burning gases. These rings were turned from the solid metal and were bored axially and radially so that there is a minimum thickness of only 0.7 in. of metal between them and were connected by suitably large passageways which permitted the cooling water to circulate through them in a zigzag direction. The cooling rings seated against the cylinder liners on sloping surfaces, which was also an important construction detail.

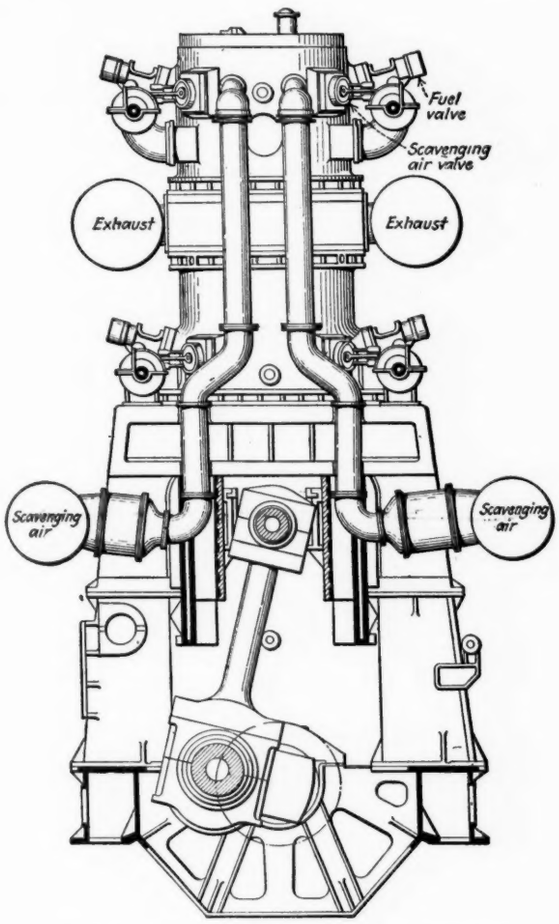


Fig. 3—View of 12,000 hp. Diesel engine

Similar difficulties were also experienced with the design of the cylinder heads and the pistons. Here again it was deemed best from experience to carry off the excessive heat by cooling water that circulated across the heating surfaces at high velocity.

The temperature measurements taken in a single cylinder that was not equipped with cooling rings are of interest. Some of these measurements are shown in Fig. 2. These permit the results to be compared with those obtained by Chief Engineer Alt, on a four-stroke-cycle U-boat engine. Here the greatest temperature drop noted with 138 lb. mean effective pressure was 155 deg. F. In the Nürnberg engine the temperature drop amounted to 280 deg. with a mean effective pressure of only 95 lb. This high temperature difference is characteristic of the two-stroke-cycle principle and limits the ultimate practical size of the cylinder owing to the structural difficulties presented.

What is an Engineer?

By William V. Fitzgerald

What does the general public think about the engineer? It is difficult to say definitely because of the many phases of the popular mind and because of the various meanings that may be applied to even a single word, to say nothing of a highly complex branch of the world's work. But it is practically certain that the general public has at best a hazy conception of what really constitutes the business of engineering; that is, the practical every-day business of engineering.

And the general public is not altogether to blame for its hazy conception. Today there are more kinds of engineers than there are industries. There are civil, mechanical, electrical and chemical engineers, and there are industrial, refrigeration, lubrication, operating, efficiency, radio and construction engineers—and a thousand and one other varieties that we will not stop to mention. But there is one thing that can be done to dispel the haze, and that is to impress upon the public that the engineer is essentially *a man who does things.*

Two Kinds of Engineers

The general public sees a man in overalls, dirty greasy overalls, starting up a steam shovel in a vacant lot, and says to him, "Are you an engineer?" And the reply is, "Yes." The same question is put to a man wearing spats, tortoise-shell glasses, a dapper suit of the latest cut, nails manicured to the quick, who sits all day at a desk and whose most ardent exertion is to bite off the end of a new cigar when the old one has become uncomfortably short—the same question is put, and the answer "Yes" is heard in tones that would suit any 4 o'clock pink tea.

Here are two men, totally different in appearance, in character, in habits, but identical in that the goal of their efforts is the same—provided they both are honest-to-God engineers. But that is just the point—Where does the man on the steam shovel lay his claim to brotherhood with the man in the shell glasses and spats, when there is apparently such a gulf between them?

Technically, they may both be classed as engineers. The public, however, is so busy and so much concerned with its own affairs that it does not bother much about it either way. Men who invest dollars in engineering projects, in manufacturing and developments of one kind or another, are the only ones interested in the engineer—and not because of what he knows, so much as because of what he can do with what he knows.

People know that Marconi made wireless possible, but they hardly think of him as an engineer. They think of what he did and not the "technique" of his doing the thing. They know of the work of Edison, but they associate him with the incandescent bulb and the phonograph. They do not think of the mathematical formulas which denote what Marconi or Edison did, but they think of the things they did. For these things preceded the formulas and laws—"the technique" of the work.

The Wright brothers, when they made their first successful flight in a "heavier than air" machine, even the first successful "glider," disrupted all the theory and formulas that were in existence relative to such things. Their practical demonstration proved the error of the formulas, and when the error was proved, men set about making new formulas in accordance with what had been demonstrated.

So it is difficult to define the word "engineer." The man of the other profession does not consider the engineer-neighbor whom he sees every day, as a co-worker with Edison and Marconi. He fails to grasp any connection between the commonplace life of the man he knows and the marvelous inventions that the world talks about. But in a strict sense the same strain runs in the man who operates the steam shovel in the vacant lot and in the great inventor. Both are engaged in working the materials of the world for the benefit of the world. In so far as a man does that, and does it in the best manner possible, that man is an engineer of a high order, although his capacity may be more limited than that of another.

Results Are the Real Criterion

Let us consider the man in the overalls. Is he an engineer? Can we define the word so as to include this man? If not, what is it that will place him outside the pale of the classification?

He cannot be disqualified because his hands are dirty and his overalls messed up with grease and grime. If he can be so disqualified, then the surgeon is eliminated from his profession when he becomes mussed up with the gore of the operating room. Any man in any work has the privilege of becoming dirty with the dirt peculiar to his work. He cannot be disqualified because he has not acquired the dignity of a courtier—or a butler. Neither can he be disqualified by his political belief or lack of any political belief.

The man must be judged solely by his ability to apply the principles of science to the work in hand. If the man on the steam shovel knows how to burn a pound of coal and get the greatest amount of heat out of it; if he knows how to apply the heat, generated by the pound of coal, to a boiler to produce the greatest amount of steam; if he knows how to apply the steam so generated to the work of moving earth or rocks or other material in order to provide homes for men to live in, or water for them to use, or canals for their ships to sail upon—then he is no less an engineer than the Edison who invents an electric light or a phonograph, though his field of endeavor may be different.

The "School-Made" Engineer

Then there is the other extreme, the man with the tortoise-shell glasses and the spats. Is *he* an engineer? Perhaps he is. He has come through by the way of the school and the classroom. He has learned from the printed page the principles involved in handling the materials of the world. He has learned names for the things that the other man knows only by their manifestation as he has seen them every day in his work. The school-made engineer calls a portion of heat a "B.t.u." because he has been told that a pound of water raised one degree Fahrenheit requires that amount of heat to do it. He has been told that a pound of coal contains so many thousand of these "B.t.u." and juggles figures back and forth from B.t.u. to calories so fast as to make one's eyes bulge.

The school-made man can tell you how many pounds pressure will be required to shear a bar of steel an inch in diameter. He can tell you how many foot-pounds of work it takes to make a horsepower. To this engineer a horsepower means a number (33,000 ft.-lb. per minute) written on a piece of paper. To the man on the steam shovel a horsepower means a load of earth moved from the pit to the cars, or it means a load of

brick moved from the cars to the ship's hold. The shearing of the one-inch steel bar means so many aches and pains and so many minutes of effort. One man knows the *names*, the other knows the real things.

What is the difference what terms you put it in? These names are only a convenience in talking about things, and after all they are only names—an empty shell, without the practical application to the dirty, grimy things of everyday life.

What must the engineer be? Shall he be a man who *talks the language of engineering* or a man who knows the practical values of things? How many times have we heard of the beautiful machine that has been designed with the maximum care, with great calculation and scientific thought, only to find that when everything had been done, the thing was not practical.

The writer knows of a specific case where an engineer induced supposedly sane business men to finance a model rotary gas engine which was to revolutionize the whole world. When, after much elaborate and highly technical talk, the designing engineer finally completed the model, all his efforts to start the thing were of no avail. He had not thought of the necessity for obtaining compression for the fuel mixture. Any common operator of a gas engine could have told him that there would be little power, if any, developed without compressing the gas before firing. Anyone who has tried to crank an old automobile when there was little compression could have told him that the gas would not be overanxious to explode without providing some means for adequate compression. But the thing was financed upon "technique" rather than engineering ability, like many another more costly and disastrous project.

Language Is a Help

It would be well if every practical man could know the *language* of the things he uses, if he could acquire the names and formula by study. It would give him the opportunity to express his opinions convincingly and conclusively, whereas, when he voices his ideas without the language, though he may be right and know he is right, his expressions sound weak and feeble in comparison to the sophisticated verbiage of his scholastic brother. His worth-while realism is often cast aside in favor of impossible figures that are based upon formulas.

Real engineering is the application of basic laws and principles to the problems of life. It is the reason for the study of the laws and principles, but the learning of them does not make an engineer. All development has been the result of trial and failure. Names and formulas have been established, and they have been shot to pieces when practical application has found them wanting or when new discoveries have been made. New names and new formulas have supplanted them. Practice has always preceded the laying down of "laws." Science has never done anything more than to discover the existence of principles, usually prescribing causes for observed effects.

So it is difficult to define the term "engineer." Somewhere between the two extremes—the man on the steam shovel and the man in the tortoise-shell glasses —will be found the real engineer. His work must be practical no matter how much theory he may know. The thing he builds must work and work *economically*. It matters little whether Edison juggled this or that material in varying proportions until he found the right combination, or whether he went at it with pencil and pad and dug it out mathematically. Whatever way he took to do it, the thing works—and that is the acid test—it works and is of value to all mankind.

The greatest engineer is the man who knows the language of engineering and who also knows the things he talks about. He knows the books and also gets his hands dirty. He works out formulas and also pounds steel with the peen hammer. He may learn the practical first and deduce the theoretical from the practical, or he may learn the theoretical and the practical at the same time, but no matter when he learns the theory or how well he learns the theory, he will never be an engineer in the true sense of the word unless he can apply the knowledge to the common, every-day things of life. Such men are recognized as professional men and not only as professional men, but as benefactors of the world at large.

Stopping Alternating-Current Elevators

With single-speed alternating-current elevators the dynamic braking action by the motor is unobtainable for assisting in stopping and recourse is placed entirely upon the mechanical brake for stopping. This has been found satisfactory for the lower car speeds, but as modern practice demanded higher speeds, difficulties were encountered to meet these conditions. It is a simple matter to provide a sufficient mechanical braking action by increasing the brake size or number of brakes, but this manner of surmounting the difficulty could not be considered good practice.

As the principal factor in stopping an elevator is the braking action necessary to bring the motor's rotor to rest, it is readily conceived how heavy strains may be developed in the rotor shaft when stopping quickly. The mass of the rotor is at a comparatively long distance from the shaft with respect to its radius, and this mass must be brought to rest by applying a retarding force to the shaft through the agency of the brake wheel or wheels as the case might be. The shorter the time in stopping the greater the force that must be applied and the greater the strain imposed upon the shaft. The ideal location for the brake wheel would be upon the rotor core, where the greatest opposition to stopping is obtained. Under this condition there would be no strain imposed on the rotor shaft and at the same time the strains imposed on other parts of the equipment would be practically unchanged.

Higher elevator speeds for alternating current brought out the two-speed alternating-current elevator motor, where, by slowing down to low speed before stopping, a positive stop may be obtained with but little effort from the brake. Any other method of stopping should not be desirable as the duty imposed upon the brake and the strains applied to other parts of the equipment are subject to the will of the elevator operator.

Correction—An editorial in the Feb. 26, 1924, issue, "Progressive Engineering in Grand Rapids," mentioned a municipal heating plant. This was instead, a plant of the Consumers' Power Company of Michigan. Three ranges of pressure are furnished, namely: 1 to 5 lb. for general heating, another at 50 and another at 100 lb. instead of 2, 8 and 100 as mentioned.

Testing Differentially Connected Relays

Detailed Instructions for Testings Before the Generator Has Been Put into Service and While the Generator Is in Operation—How To Make Periodic Tests

By C. M. KING

DIFFERENTIAL relays may be utilized to protect either delta or star-connected generators, but since the latter connection is the one almost universally employed, methods of testing these relays only when applied to star-connected generators will be outlined here. For a description of this class of relay operation the reader is referred to the article, "Differentially Connected Relays for Protecting Electrical Machinery," page 210, Feb. 5 issue. After the control and relay wiring has been completed and the generator ammeters have been found to be correctly connected, tests should be made to prove that the differential relays will function properly. Directions for making suitable tests of this description follow:

1. Treating the differential relays as excess-current relays, block the relay contacts to prevent the opening of any switches. Leaving the tripping connections intact, disconnect the winding of one relay from the transformer-secondary wiring and test this relay to determine if it operates properly, by passing a current through the coil. Testing current can usually be obtained from an alternating-current lighting circuit, reduced to any desired value by means of a lamp bank or a small rheostat. If a portable ammeter is not

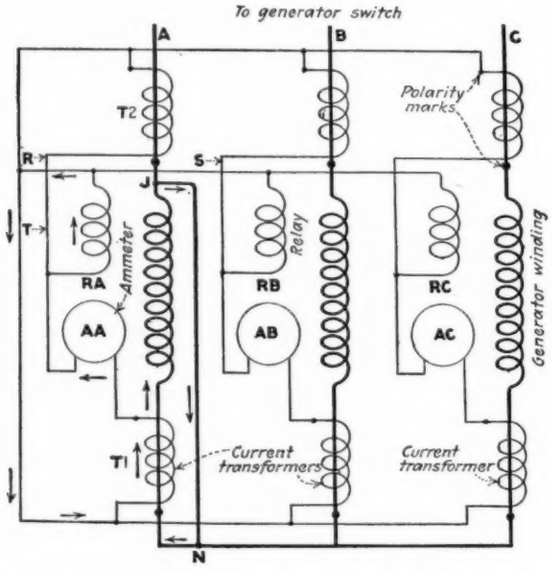


Fig. 1—Connection for testing if relays will operate with fault in one phase

available, one of the generator ammeters may be used to measure the testing current.

2. For the final test remove the blocking and observe if the generator and field switches open in the proper sequence when the relay contacts are closed by the application of testing current. The generator disconnectors should be open and the field winding disconnected during this test.

3. Test each differential relay as specified under 1 and 2. After the completion of these tests and the correction of any defects it will be known that each relay will function properly when sufficient current is applied to it.

4. With relay and control circuits normal connect a cable of ample carrying capacity between points *J* and

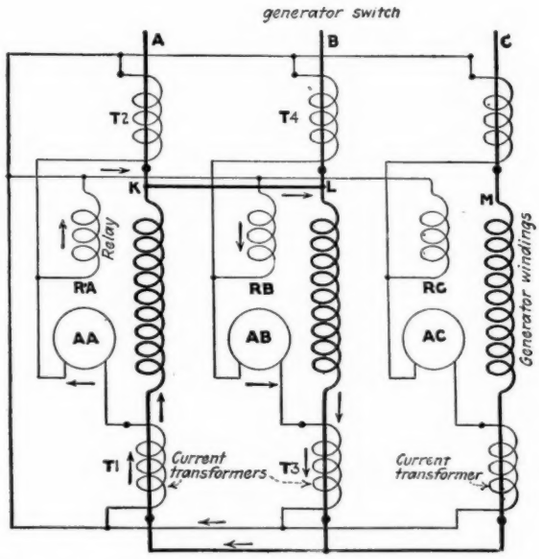


Fig. 2—Connections for testing if relays will operate with fault between phases

N, as shown in Fig. 1, thus short-circuiting one of the generator windings. Note that current transformer *T2* is outside the short-circuit and that *T1* is included in the generator circuit. The circuits for both the generator and relay currents are indicated by arrows. A cable to which lugs are attached can usually be bolted or clamped to the conductors without difficulty. With the disconnectors open close the generator and field switches. Operating the generator at reduced speed, apply enough field current to cause sufficient current to flow through the short-circuited winding to trip *RA*, the relay protecting this phase. Note the current required to trip relay on ammeter *AA*. As a further check an ammeter may be connected directly in series with the relay under test, or an ammeter may be connected to a current transformer inserted in the short-circuiting cable, but ordinarily the generator ammeter is sufficient. Current will flow in the secondary wiring as indicated by the arrows. Owing to their high impedance negligible current will pass through the secondaries of the current transformers not included in the path of the short-circuit current.

5. Determine if relays *RB* and *RC* function correctly when phases *B* and *C* are short-circuited to the neutral bus, as specified under 4 for relay *RA*.

6. With the generator at rest and its disconnectors open, connect the short-circuiting cable between points *K* and *L*, Fig. 2. Again operating the generators at reduced speed, increase the field current until the current in the short-circuited phases becomes great enough to trip relays *RA* and *RB*. Ammeters *AA* and *AB* should each indicate the magnitude of the current energizing these relays.

7. Short-circuit points *L* and *M*, Fig. 2, and upon the application of sufficient field current relays *RB* and *RC*

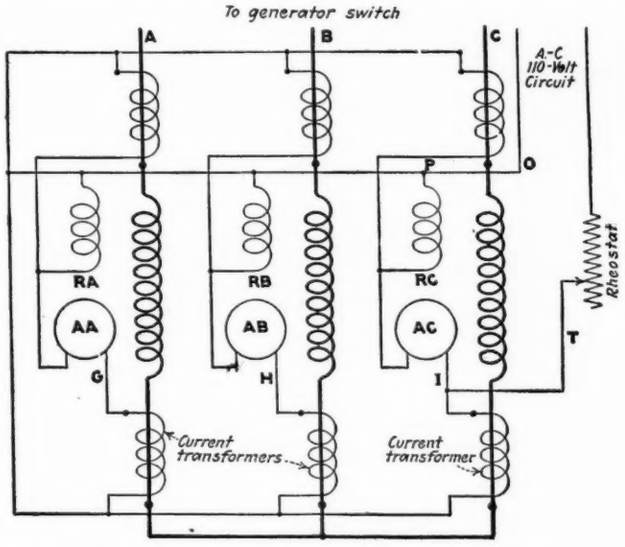


Fig. 3—Connections for making routine tests of relays operation

should function, the tripping current being read on ammeters *AB* and *AC*.

8. Short-circuit points *M* and *K*, Fig. 2, and upon the application of sufficient field current relays *RA* and *RC* should function, the tripping current being indicated on ammeters *AA* and *AC*.

If the foregoing tests result in correct relay action and switch operation, the generator will be disconnected upon the occurrence of internal trouble. After any changes have been in the current-transformer wiring, tests 4 to 8 inclusive should be made to ascertain that the differential-relay connections are correct.

Testing Relays with Generator in Service

By blocking the relay contacts it is possible to test the differential relays while the generator is in operation, but such a procedure is not to be recommended. One method of making a test of this description is to short-circuit a pair of current-transformers secondaries in one group, such as between points *R* and *S*, Fig. 1, then by opening one wire, as at *T*, the secondary current from transformer *T*1 must pass through relay *RA*, and if great enough, this relay will be tripped. After closing the circuit at *T* and removing the short-circuiting connection, relays *RB* and *RC* can be similarly tested. During this test the relay current can be varied by changing the generator's power factor or load

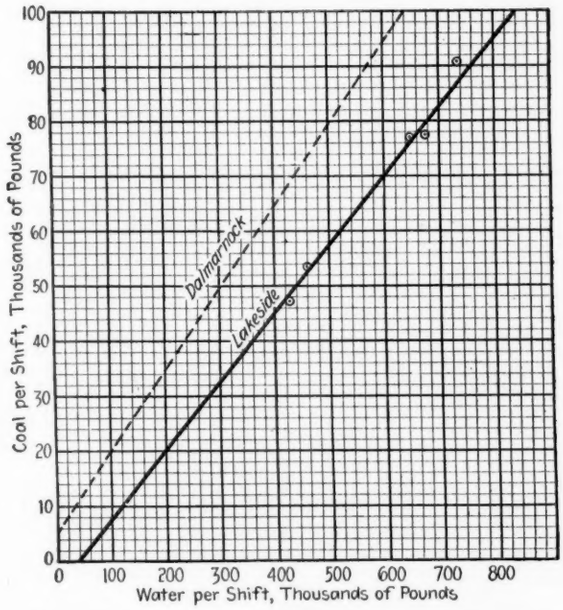
Over-All Monthly Test

Conditions permitting, it is advisable to make an over-all test of differential relays at monthly intervals. This test must be made with the generator out of service, and one satisfactory method is to use connections as shown in Fig. 3. Lead *O*, from a 110-volt alternating-current circuit, is connected at *P* to the wire common to the three relay coils and the six current-transformer secondaries, and the other lead *T* is connnected in turn to points *G*, *H* and *I*. With relay connections as shown, current can flow from each of these points through one relay and one ammeter. Since the scales of generator ammeters are marked for primary amperes, the current actually flowing in the ammeter and relay winding under test can be found by dividing the ammeter reading by the current-transformer ratio. As a check on the generator ammeter a portable ammeter may be connected in series with the rheostat required to limit the current. The generator and field switches must be tripped by relay action during this over-all test to prove that all tripping and control circuits and auxiliary switches are in good order.

An International Puzzle

A discussion recently started in the British magazine, *The Engineer*, has reached a point where it is exciting international interest. To be brief, what happened is this:

David Brownlie started the ball rolling by publishing in *The Engineer* an article strongly favoring the use of powdered coal. This brought down on his head a rather violent attack from the advocates of stokers. Others joined in on both sides, and the discussion



"Parsons Lines" for Dalmarnock and Lakeside

quickly reached a state of warmth quite unusual for the pages of this dignified British journal.

Recently, the discussion has become an argument between two gentlemen, Mr. Napier and Mr. Swinton, as to the reliability of the test data obtained at the Lakeside Station, whose over-all efficiency of 85 to 86 per cent had been held up by Mr. Brownlie as sufficient proof of the good results obtainable with pulverized coal.

Mr. Napier tried plotting "Parsons lines" for the Dalmarnock and Lakeside Stations. These are shown in the accompanying diagram. As the Parsons line is

less familiar to American than to British readers, a brief explanation may be in order. All the figures given are for a complete station. The coal used per shift is plotted as ordinate. The abscissa may be the water used per shift (that is to say, the evaporation per shift) or the station output in kilowatt-hours per shift. In the present case, since only the boiler room is considered, the evaporation is used.

The first step in preparing an actual Parsons line is to obtain data for a great many runs and plot these. According to many British authorities the points so obtained will lie very close to a straight line. This line can then be drawn in to give a fair indication of what the station might be expected to do at any load. Normally, the Parsons line is expected to intersect the zero output line at a point above the origin. In other words, if the curve means anything in this section, it must show some coal consumption at no evaporation to allow for the stand-by losses. But when Mr. Napier plotted five points for the Lakeside Station and drew what he considered to be a fair straight line through them, it seemed to indicate the astounding fact that the Lakeside Station would evaporate 40,000 lb. of water per hour with no coal consumption whatever. So *The Engineer*, in a recent issue, puts the dilemma up to American engineers in the following words: "From this brief examination it will be seen that it is now, as they would say themselves, 'up to' the American engineer to show why the Parsons line leads, in this case, to an absurd conclusion. Their best defense would be that there are not sufficient observations to establish the true slope of the line, but if they employ it they must impeach the 'unsurpassed' accuracy of the tests. Rather than make such an admission they may contend that the Parsons line is not necessarily straight; but that position would have to be held against a large mass of experience. If neither of these defenses of the observations can be upheld, the only course would be to admit that there was some constant error in metering either the coal or the water. We hesitate to believe, even in the face of a diagram which leads to that conclusion, that an error in calibration could have crept in. We suggest, however, that the matter cannot be left where it is. Mr Napier has raised what appears to be a very important point, and the Parsons line or the American figures must remain under suspicion until it has been cleared up."

Since the foregoing was written, another correspondent has plotted a similar line for the Dalmarnock station using only the test data for the higher loads. His line, like that for Lakeside, showed some evaporation with no fuel consumption.

The March issue of *Oxyacetylene Tips* tells how the acetylene torch was used to remove a large steam engine from a space where walls built after the installation of the engine made it impossible to remove it by ordinary methods without great expense. The flywheel was too large to pass through any opening in the building, and it was not practicable to rig up tackle to handle the 50-ton wheel. The problem was finally solved by cutting up the wheel with the blowpipe and removing it in sections. In this way it was possible to remove the engine shaft without damage. The cost of the cutting on this job including labor and gas, was $35.

Steam Boilers

A Catechism by Warren Hilleary Served in Small Doses and Extending Over a Number of Issues

97. Do you measure the diameter of a boiler on the inside or on the outside of the shell?

Inside of the course having the greatest diameter. This usually is the diameter of the boiler head.

98. Is a fire tube measured from the inner or outer diameter? A water tube?

When ordering either fire tubes or water tubes, the outside diameter should be specified, but when computing the collapsing pressure of a fire tube its outside diameter should be used, while when computing the bursting pressure of a water tube its inside diameter should be used. On the other hand, when determining the heating surface in a fire tube, to be exact its inside diameter should be used, while, when determining the heating surface in a water tube, its outside diameter should be used. When determining heating surface, however, it is frequently the practice to use the outside diameter both for water and fire tubes. This is because the difference between the results is so little as to be unimportant.

99. Frequently, reference is made to certain seams of all types of boilers as "horizontal seams." Technically, the word "horizontal," when applied to seams, is incorrect. Why?

If a vertical boiler were laid on its side, certain seams for the time would be horizontal, but when the boiler is again set in its upright position, then, instead of being horizontal they will be vertical. To eliminate the possibility of confusion, it is proper to call side seams "longitudinal seams."

100. What governs the height of the bridgewall of a horizontal tubular boiler?

There is no well-established rule for the height of a bridge wall, but the gas passage between the top of the bridge wall and the bottom of the boiler should be from two to two and one-half times as great in area as the combined area of all the tubes.

101. How would you construct a bridge wall in a boiler that is equipped with a Dutch oven furnace?

Bridge walls are not used in connection with Dutch oven furnaces. The reason is that the construction of the Dutch oven furnace is such that a bridge wall is not required.

102. A boiler is to be laid up for a season of several months. What preparations should be made?

(1) Thoroughly clean all parts (internal and external) taking especial care to dry both inner and outer surfaces, and see that all valves are wide open. This method may be followed best in dry climates.

(2) Fill the boiler with water to which has been added five gallons of kerosene or light engine oil. Allow the water to run out slowly, requiring about 24 hours for the process. Leave all connections open.

(3) Thoroughly clean all inner surfaces and paint with a solution of plumbago and crude oil or plumbago and any other suitable retaining medium. Insert trays of unslaked lime both above and below the tubes. Close all openings in the steam space. This method may best be followed in wet climates. Lime absorbs moisture and helps to keep the boiler dry. This is a great help in preventing corrosion of the boiler while laid up.

EDITORIALS

F. R. LOW, EDITOR

The Lifeblood of the Nation

FOOD, clothes and shelter—these are the lifeblood of the nation. Without them culture, art and all the refinements of civilization are worth exactly nothing. In each of these three the work of the engineer is of paramount importance. The tools he designs and builds till the soil and harvest the crop. His railroads carry the farm products to the cities, otherwise helpless. His machines spin and weave the cloth and stitch the clothing. His sawmills and steel plants turn out the material for buildings. He generates the power, carries it wherever needed and puts it to work. He transports the gas and water, builds the roads and the bridges. If he and all his works were suddenly to evaporate, civilization would die in a week.

This is the idea, presented in somewhat different form, that Ira Hollis, past-president of the A.S.M.E., implanted in the minds of his fellow engineers at a recent gathering in New Haven, Conn.

Its truth is self-evident. It is also true, as there pointed out, that the permanency of this and other nations is bound up with productivity, which in turn is absolutely dependent upon the work and guidance of the engineer.

Only as engineers play an ever-increasing part in the life of the nation can production increase to meet the needs and aspirations of a steadily growing population.

Utilizing Boiler Blow-Down

FEW plants, after they have been put into operation, have developed the efficiency estimated by the designing engineer. This is generally due to operating contingencies that have been overlooked in preparing estimates. One of these which is seldom considered is the boiler blow-down.

The extent of the heat losses from this cause depends on the character of the feed water entering the boiler. In plants where water with scale-forming material in solution is allowed to enter the boiler together with boiler compounds to prevent the formation of hard scale, blow-downs must be frequent and relatively large in amount. Where the water is softened by soda-lime or similar processes, the water entering the boiler will contain large amounts of alkalies such as sodium sulphate, which must be removed by frequent blow-downs on account of their foaming propensities when concentrated by boiler evaporation. It will thus be evident that boiler blow-down is a necessity in all plants except those with evaporators and is even necessary to some extent in such plants owing to the impurities that enter through condenser leakage.

Many engineers have considered the possibility of utilizing the heat of boiler blow-down water which leaves the blowoff valve at full boiler temperature. A recent suggestion is to provide a continuous blow-down into a multiple-effect evaporator. It can be shown that there is enough heat in the blow-down of a high-pressure station to furnish at least three-quarters of the equivalent makeup water in a triple-effect evaporator, and furthermore, if the final condenser be made a part of the feed-water heating system, practically all the heat in the blow-down is recovered as well. The rate of this continuous blow-down can be regulated so that concentration in the boiler is held at a low figure.

Small multiple-effect evaporators are not available at reasonable figures for this service, and it is questionable if the extra complication and attention necessary is warranted except in large central stations. Another possibility is to carry the continuous blow-down to the regular evaporator and thus replace so much raw water. Blow-down used in this way can be made to recover a large percentage of its volume in makeup, and also the greater part of its heat will be finally available in the evaporator condenser, which may be used to heat the feed water.

It is quite true that these practices will result only in small savings, but these are pretty certain. Besides, there are operating advantages that warrant careful consideration of these uses of boiler blow-down.

Superpower and Giant Power Versus Fuel Conservation

MUCH has been said about the superpower idea, involving nation-wide interconnection and the utilization of steam and electric plants at more favorable load factors than at present. In the State of Pennsylvania there has risen a similar movement, referred to as Giant Power, the policies of which appear to be on somewhat broader lines.

In comparing, Morris L. Cooke says, in the March issue of *The Survey:*

> Essentially this superpower idea consisted almost entirely of a tying-in of existing facilities and the gradual elimination of the units operated at relatively high cost. Byproduct recovery was only casually mentioned. Some of the largest stations were to be located on tidewater, thus requiring the indefinite continuance of the uneconomic transportation of coal long distances from the mines. There is scant mention made in the superpower report of the interest which the small user—especially the farmer—has in lower rates and wider distribution.

Further advantages of the giant power idea are described in the same magazine, by Gifford Pinchot:

> Giant power is also the equivalent of the sum total of controlled and interconnected mechanical energy within an area the limits of which are fixed—not arbitrarily as by state lines or by the historical development of some public or private enterprise, but by technical considerations. . . . Giant power means the practice on the broadest possible scale of every possible economy such as the pooling of stand-by facilities and the elimination of every waste, such as that due to a low power factor.

The general public, not versed in engineering mat-

ters, will undoubtedly be impressed by the advantages to be derived from these plans. There may be a latent dread on the part of some at the thought of placing such an important thing as universal power into the form of a giant monopoly. Many engineers are keenly aware of the fact that while sources of waste, such as low power factor, undesirable load factor, etc., may be reduced, there is apparently a total disregard of the matter of fuel conservation in its broader sense.

Two "superpower" plants, with ultimate capacities of 500,000 kw. each, are being completed in the vicinity of New York City. At full load one of these plants would, in one hour reject into the harbor, heat equivalent to that in about three hundred tons of coal. This would supply forty families with heat for all winter. At fifty per cent load factor, the heat thus wasted during three months would keep fifty thousand homes in warmth during the cold season.

Many small plants utilize the heat in exhausted steam, so that the waste of fuel now practiced in condensing plants is largely avoided.

With such men as Gifford Pinchot back of the giant power movement there is undoubtedly some hope that broad fuel conservation will receive attention. In the meanwhile, as education is going rapidly forward, many wonder why the public are carefully left uninformed of the giant waste representing more energy than the sum total of expected economies.

Limitations of Automatic Control for Hydro-Electric Plants

SINCE the first automatic hydro-electric station was put into operation in 1917, the use of this class of equipment has increased until such stations are in operation in practically every state in this country, in capacities ranging up to five thousand kilowatts. These stations have made economically possible the development of many water-power sites that would otherwise be too expensive to operate. In some sections of the country it is so isolated and lonesome that it is difficult to maintain an operating force at the station with the assurance that it will be on the job in case of emergency. With the automatically controlled station these limitations and others have been removed.

From the technical viewpoint there does not seem to be any limit to the capacity of hydro-electric plants for which automatic control can be designed. From the point of view of maintaining an operating force at the station, it also becomes a question of balancing the cost and maintenance of additional equipment against the cost of operators. Where large stations are involved, the cost of the operating force is small compared to the value of the output. Therefore, from this angle, complete automatic control will probably never be advisable in the large plants.

There is, however, an influence that may further limit the size of automatic hydro-electric plants; namely, How many more kilowatt-hours can a good operator get out of the plant than can be obtained by automatic control? Many of those who operate hydro-electric plants are beginning to realize that the water available at the plant for power development is valuable even though the water man does not render a weekly or monthly bill, as the coal man does to the steam plant. This is leading to careful analysis of water-power plant operation with the object of producing the maximum output per cubic foot of water available, something that was scarcely thought of a few years ago. Where an automatic station is operated intermittently, the leaks through the turbine gates, during the periods that the machine is out of service may amount to considerable. In at least one case, it has been found more economical to maintain an operator at the plant who, among his various duties, closes the penstock valve when the plant is shut down. Some method of completely shutting the water off from the turbine when it is out of service would do much to enhance the possibilities of the automatic hydro-electric plant.

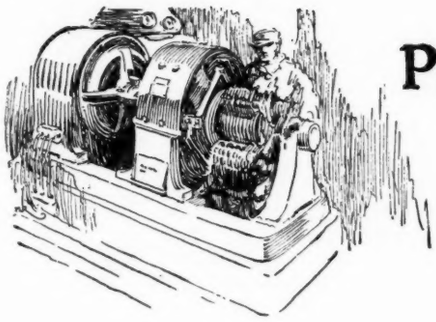
There is the possibility of combined automatic and manual control for large plants, which is being provided for in at least one plant. If the plant is made so that the machines can be synchronized automatically, the danger of performing this function improperly by the operator is removed. On the other hand, in case of trouble on the system the operator need not give his attention to getting the machines into service, since, as soon as conditions are correct for them to come on the line, they will do so automatically. This permits the operator to give his attention to other details of operation and allows restoring service in a minimum of time. These two factors—economy of operation in the smaller stations with automatic as compared to manual control and in the larger stations of making them partly automatic—will undoubtedly have an influence on the limits to which automatic control may be applied to the operation of hydro-electric plants in the future.

Suggested Evaporating Coil Design

IN VIEW of the wide divergence between steam and refrigerating practice as referred to design equipment that has heretofore prevailed, it is surprising to find that a number of refrigerating plants lately designed reveal a tendency to follow more or less steam practice. This applies particularly to the general acceptance of the shell and tube type condenser.

In the evaporating side, while shell type brine coolers are coming into general use, designers still adhere in the coil system to the use of coils of one to three thousand feet in length. The frictional resistance of such coils is high and the velocity of the gas and liquid is of a low value.

The process of heat absorption in the can-ice tank and storage rooms is essentially similar to that of the boiler plant. The boiler designer early found that the tube length must be fairly short if a rapid circulation was to exist. It was also early agreed that the tubes of the water-tube boiler should be placed below a drum in order not only to provide a supply of water for the tube, but also to give an additional head which increases the velocity of circulation. Admittedly, the flooded type of evaporating coil achieves this object, but only to a minor extent, for the coils are usually very long. As a suggestion would it not be advantageous to design the system along the lines of a cross-drum boiler? At each end of the tanks a header could pass down between each row of cans and be connected by comparatively short lengths of piping. The accumulator or, more properly, the drum could be mounted above the tank sufficiently high to give ample headroom. There is every reason to assume that circulation and heat transfer would be improved and the complete flooding of the coils assured.



Practical Ideas *from* Practical Men

Buying Equipment on Specification

Porous and defective castings cause the power-plant owner important losses in operation and maintenance. The inferior quality of the castings coming through many foundries today is almost unbelievable. It would indeed, be a good plan for the plant owner and chief engineer to specify that all castings be shipped without filler, or paint, as it is comparatively easy for the manufacturer to cover up the porous castings that have been peened tight or plugged with pipe plugs or burned tight with the welding outfit.

Numerous castings go through with thin places, resulting from slipped cores, etc., which the purchaser never knows about until a slight overpressure results in failure, which he promptly blames upon the operating engineer.

It is also true that not all of the defective work can be traced back to the foundry. The machine shop comes in for its share of poor work. The writer (like other engineers that have served time in the shop) could recite numerous instances of castings that leaked like sieves while being tested on the test floor, yet they were peened and plugged and burned, until they would just show tight, then filled and painted, and pushed out to the customer. It hardly seems fair to send such defective and doctored up equipment to the power plant owner and the unsuspecting steam engineer, because I know by experience that the great majority of plant engineers have great faith in the manufacturer, with the result that equipment is usually accepted without rigid tests of any sort, not even pressure tests; with the result that *he*, the plant engineer, gets blamed for carelessness or laxity in operation a little later on. Whereas, if the proper tests of acceptance had been made at the outset the steam turbine, centrifugal pump, or cast-iron receiver, whichever it may be, would have been thrown back to the manufacturer for him to make right according to specifications.

The old custom of requiring the manufacturers to meet certain fundamental specifications as to material and workmanship and then to submit his specifications as guarantees, seems to be termed old-fashioned by many of the new type of high-powered salesmen, who are interested only in making the sale and therefore play safe, legally, so that the purchaser has no come-back,

In conclusion I would suggest that the plant owner, and his engineers get back to the old custom of specifying the following requirements, and then to require the agents or salesmen to submit complete specifications, and finally to make complete acceptance tests, either at the plant where built or on the purchaser's premises.

1. Castings to be of close-grained cast iron, free from sand holes and porous spots; the metal must be properly distributed and generously proportioned so that the assembled machine will withstand a pressure test of at least twice the working pressure without leaks. Small drops are permissible at bolts and flange joints on underwriter fire pumps. This is entirely fair to both parties concerned.

2. All castings should be shipped without filler or paint where proper tests are not conducted at the manufacturer's plant, with customer's inspector on hand to witness tests.

3. The exhaust side of steam turbines and engines, also the suction side of steam and centrifugal pumps, should be designed for the maximum pressure. The practice of using low-pressure flanges and drilling, on the suction side of high-pressure centrifugal pumps is dangerous where several pumps are connected to the same line. This in particular, applies to boiler feed pumps, since automatic relief valves are not reliable on boiler feed water, owing to sticking of the valve caused by solids in the water.

4. Bearings on steam turbines and centrifugal pumps should be protected from steam or water blowing along the shaft into the bearings. Several good methods of preventing this are used. However, many builders do not think this important, but the operator knows differently by sad experience.

5. Babbitt bearings should be poured to a mandrel, smaller than the shaft, and then turned down sufficiently so as to eliminate all porous and soft spots and secure a solid uniform bearing. The bearings should be scraped to a fit and not reamed. Centrifugal boiler-feed pumps and small steam turbines should be fitted with bronze bearings where they are not water cooled.

6. Castings should be of sufficient thickness to overcome leakage at chaplets. Peening is permissible provided the casting is heavy enough to stand it.

7. If pipe plugs are used to stop leaks in castings, they should not be chipped off flush and filled with a view of deceiving the customer.

8. The use of sal-ammoniac solutions to rust porous castings tight is not permissible.

9. The use of packing or wicking under nuts to cover up leaks around studs temporarily should not be permitted.

10. The use of litharge to cover up loose studs or stud holes drilled through the castings, should not be permitted.

11. Shrinkage cracks must not be covered up with the welding torch.

12. The pressure and hammer test should be used to uncover cold shots, and porous spots on apparently smooth sound castings.

WALDO WEAVER.

Tonawanda, N. Y.

Paralleling Three-Phase Banks of Transformers

In placing a bank of three new 500-kva. 2,300- to 21,000-volt step-up transformers in service recently, I had an interesting experience. These new transformers were to be connected delta to delta in parallel with four banks, of similar rating but of another manufacture, that had been in service about fifteen years.

Arrangements had been made with the manufacturer of the new transformers for the same ratio of transformation and the same impedance drop as were characteristic of the old transformers. All four banks of the old transformers were connected as shown in Fig. 1. The new transformers had a diagram on their name-plate similar to this figure. The natural supposition was, therefore, that they could be connected in this manner and placed in service.

Before proceeding to do this, however, it was thought advisable to make a few tests to be absolutely certain that this connection was correct. No mention of polarity was made on the name-plates of either the old or the new transformers. One transformer of the old banks and one of the new bank were accordingly tested for polarity, as shown in Figs. 3 and 4. Alternating current at 110 volts was connected across the high-tension winding, a jumper connected across one end between the high- and low-tension winding and a voltmeter across the other.

The transformer from the old bank proved to be of additive or positive polarity, as shown in Fig. 3, while

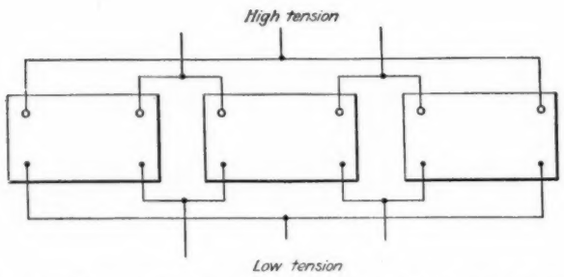


Fig. 1—Diagram showing how the old transformers were connected delta-delta

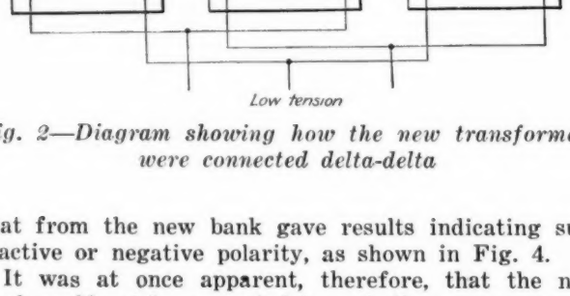
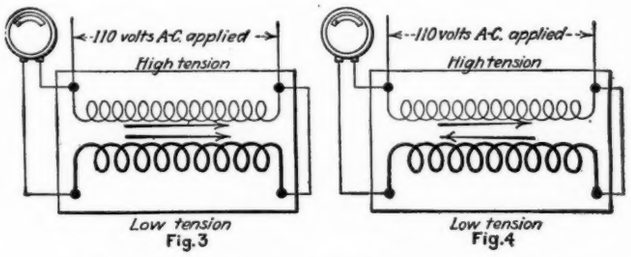


Fig. 2—Diagram showing how the new transformers were connected delta-delta

that from the new bank gave results indicating subtractive or negative polarity, as shown in Fig. 4.

It was at once apparent, therefore, that the new bank could not be connected in a similar manner to the old ones. The leads on the low-tension side only were interchanged at each transformer and the connections arranged as shown in Fig. 2. As a final check one lead from the low-tension side of the new bank was connected to one busbar, after which the high-tension side was connected. A voltage instrument transformer with voltmeter was connected first between one of the remaining low-tension leads and the corresponding busbar, then the other lead and busbar. In both cases no



Figs. 3 and 4—Connections for testing polarity of transformers

reading resulted, indicating that the connection was correct. The bank was then placed in service and operated satisfactorily.

FREDERICK KRUG.

Bayamón, Porto Rico.

Why the Hoist Motor Failed on Load

Several years ago I was given the job of connecting up an electric hoist that was driven by a 40-hp. direct-current compound-wound motor, remote controlled, the controllers being located a considerable distance from the motors. Upon completing the job, I tried the hoist without a load and everything worked fine. The next day the chief electrician gave the motor a good try-out without a load and it worked satisfactorily. But when the load was applied and the controller handle was moved over the "raise" points the load was hoisted easily until the fifth and last point on the controller was reached. Here the motor stopped dead, and the magnetic brake went on.

I rushed down to the motor and contactor panel and found the circuit breaker had opened and the motor was quite hot. The contactor for the last point on the controller was somewhat burned and the commutator showed signs of burning.

I reset the breaker, and the chief tried the controller on the "lower" positions with the same result. We went over the equipment and checked the connections with the blueprints, tested all the circuits and examined the mechanical parts of the machinery, but could find nothing wrong. Finally, we tried the motor again without load and found it worked all right, but heated considerably and there was some sparking at the commutator. We then decided to check the brush setting again, as we had noticed previously that the brush yoke was set on the neutral mark. We had also noticed that the markings on the yoke and frame were not properly made. After shifting the yoke to what we considered the proper position, we applied the load and the hoist operated perfectly.

This experience taught me that the manufacturer can make mistakes as well as the rest of us. I have connected several direct-current generators since that time which acted practically the same way and found that in nearly every case it was due to an error in the brush setting.

M. E. BELL.

Riverbank, Calif.

Comments from Readers

High-Pressure Steam Lines of Great Length

I notice in the editorial in the Feb. 5 issue regarding high pressure steam lines, also on page 216 in an article by E. E. Scott, that an 8-in. high-pressure steam line 3,610 ft. long, is believed to be the longest in the world.

This company in 1922 erected a 12-in. steam line for 250 lb. working steam pressure which was about 4,400 ft. long and was welded up solid by our special method of welding, with the exception of one pair of flanges at each of two cast-steel tees and one flange at each end of the line.

We also installed, in 1918, a 14-in. steam line for 225 lb. pressure, about 3,000 ft. long, 800 ft. of which was under a railroad yard and was welded up solid.

HENRY M. WILSON,
Pittsburgh Valve, Foundry & Construction Co.
Cleveland, Ohio.

Practical Method of Connecting Steam Trap

Referring to the articles by Mr. Van Keehern in the Dec. 4, 1923, issue and by A. J. Bell in the Jan. 1, 1924, issue, entitled "Will Changing the Connection to the Trap Improve Its Operation?" I should like to submit a method of connecting the trap which I think is more practical and will give much better results.

It would appear from the drawing shown by Mr. Van Keehern that the trap has no equalizing vent connected directly to it, as the line shown connects with the pipe ahead of the trap. In my opinion a vent, to be effective, should connect directly to the body of the trap. I notice also that there is no bypass provided. From past experience I consider a bypass necessary on every trap if trouble is to be avoided.

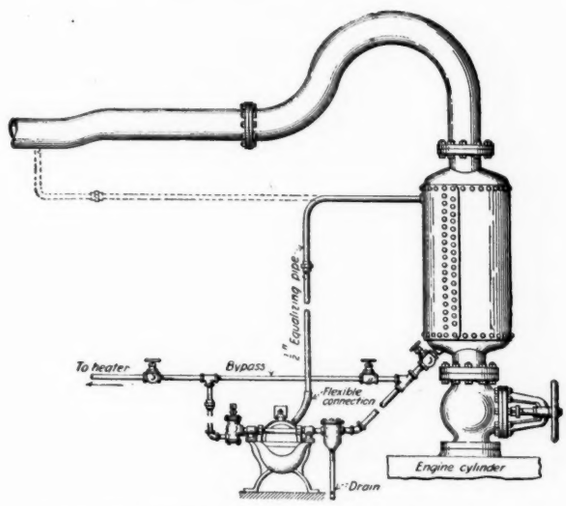
In the accompanying illustration is shown an arrangement of trap connection that I have found to give good results. Personally, I prefer a trap of the open-bucket type to the one shown, but the arrangement of the connections should be equally effective with either type. With the tilting bucket type, however, it may be necessary to provide a flexible connection as shown, between the bucket and the equalizing pipe, whereas with the other type the pipe can be connected directly to the trap body.

The advantage of the installation shown herewith is as follows: Should a slug of water be carried over from the boilers this connection will permit the water to pass freely to the trap, filling the space previously occupied by the steam, and the steam in the trap will pass to the separator through the equalizing pipe, permitting the full capacity of the trap to be utilized.

With regard to placing a check valve on the inlet to the trap as suggested by Mr. Bell, this should not be necessary. I would advise, however, that the trap be placed in a lower position such as on the floor below, and that all connections be made as nearly straight as possible.

W. A. VEDDER.
Chicago, Ill.

Commenting further on the articles by Mr. Van Keehern and Mr. Bell, I would like to recite a little of our experience here. We have had considerable trouble with a similar trap connected to the bottom of a separator on a 4-in. steam line about halfway between the boiler and turbine. It was taken apart and repacked and the steam and pilot valves were ground in. This



Trip fitted with bypass and vent connection

improved the operation, but did not keep the steam shut off tight. It would leak just enough to allow the trap to fill partly with condensate and then partly dump. This allowed steam to flow through the trap to the heater. Upon further examination it was discovered that the leakage occurred between the piston and the cylinder. To overcome this, we fitted a couple of rings on the piston, and since then we have had no trouble with the trap. Care should be taken, when assembling this type of trap. that the gasket at each end of the sleeve is compressed sufficiently to hold the sleeve rigidly in place and prevent leakage of steam at this point.

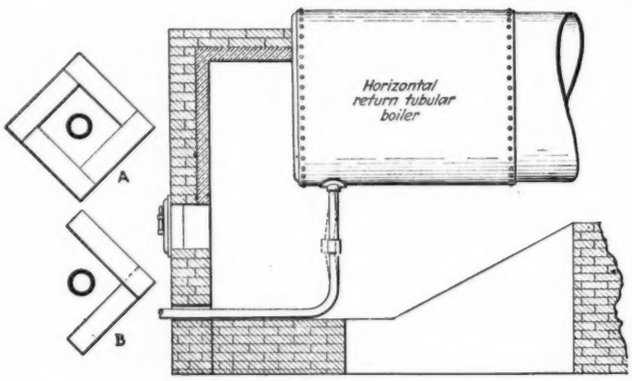
It is my opinion that the line at the bottom of the separator would be all that was necessary, because there is but little drop in pressure between this point and the point on the line, and if the steam were going through the line at any velocity at all, it would carry the condensate over the expansion gooseneck. It is also suggested that the trap be placed as far below the separator as possible to allow the water to flow by gravity to it.

B. W. HAY.
Bedford, Ind.

Boiler Blowoff Pipe Failures

In the Feb. 12 issue W. H. Wakeman cites an instance of blowoff piping of a boiler that has been in service for nearly thirty years. Thirty years is a long time for piping to last, and the obvious explanation is that the size of the pipe (4-in.) permitted a plentiful supply of water in the pipe at all times, thereby preventing overheating, whereas with the usual size (2-in.) there might have been a deficiency of water and overheating.

In a battery of boilers of which I once had charge, the blowoff pipes were made of 2-in. extra-heavy pipe and were entirely inclosed by brickwork, as shown at *A* in the illustration. Failure of the blowoff pipe was practically unknown, the only cause for renewals being external corrosion due to moisture from leaky tubes and wetting down the ashes at cleaning out time. As the protecting brickwork had to be removed to permit



Arrangement of blowoff pipe and method of insulating

inspection, and rebuilt again, the boiler inspector suggested that the brickwork be built V-shaped as at *B*. Trouble then began owing to failure of the pipe at the coupling, the failure taking the form of buckling at the coupling as shown by the dotted lines. The lower section of the pipe would also draw out of the coupling until it rested on the brickwork, which was built up to, but not touching, the blowoff pipe. Failure frequently took place within a month after renewal of the pipe (in one case within a week) and became such a nuisance that we reverted to the practice of entirely inclosing the pipe, with complete elimination of the trouble.

I do not know how other engineers would explain the cause of the failure, but my opinion is that steam was generated in the pipe and prevented the water from flowing down into it, with the result that the pipe became overheated to such an extent that the metal was softened so that the pipe threads would not hold.

Toronto, Ont., Canada. R. MCLAREN.

Indexing and Filing Articles

Indexing and filing of articles that appear in technical publications, so that the information is always available for quick reference is a problem that confronts every office manager in engineering work, and I always read of others' experience and practice along this line with a great deal of interest.

My system is not unlike the one described by Mr. Hodgins in the Feb. 26 issue. I preserve all copies, remove advertising material, attach index, punch and bind in the same manner, but I make four volumes (three months to each) instead of two, as I find them easier to handle, using "Acco" fasteners in place of lacing. I have been using paper covers, which do not stand up very well and are soon torn and faded, and I would like to know more about the type of cardboard cover Mr. Hodgins uses, whether a special cover made to order and why, like most cardboard, it does not crack and break, leaving unsightly volumes.

In addition to filing *Power* in the manner just described, I keep a card index by subjects of any articles that are likely to be useful for future reference, and in this way I save the time it would take to look through several indexes by having all that has been printed on the subject on one card. In this way one can see at a glance what has been written on the subject over a period of years.

I also keep what we call "Data Books," one subject to each book, such as steam plants, hydraulic, electrical, etc., and in these I file copies of articles of special interest or parts of the articles, photostats of cuts, tables, etc., and reprints, when they are obtainable, of any specific article that we feel is of special interest to the business. In this way we try to keep on hand as complete as possible a record of all data of interest in our particular lines of work. GORDON I. WHITE.

Boston, Mass.

Relative Cost of Bled Steam

In an article in the Feb. 26 issue, H. D. Fisher describes a method used in figuring the cost of bleeder steam in a plant in which he works. I should like to point out that Mr. Fisher's method of calculation, while good for some conditions of operation, does not take into account the heat returned to the system in the condensate from the bled steam. It is not known whether or not this condensate is returned in Mr. Fisher's plant, but it is thought that it would be well to point out a method of calculation that would permit of taking this returned heat into account. In doing this, the following symbols will be used:

H_s = Heat content of live steam, B.t.u. per lb.;
H_b = Heat content of bled steam, B.t.u. per lb.;
W_n = Steam to bleeder turbine without bleeding, lb.;
W_b = Steam bled, lb.;
W_t = Total steam to turbine when bleeding W_b lb. steam;
T_r = Temperature F. of condensate from bled steam;
T_c = Temperature F. main unit condensate or makeup water;
B = Weight of steam that must be added to turbine per lb. bled steam.

It is easily seen that

$$B = \frac{W_t - W_n}{W_b}$$

By inspection it will be evident that the extra heat added to the turbine system by the boiler when bleeding W_b pounds of steam with condensate returned, is equal to

$$(W_t - W_n)(H_s - T_c + 32) - W_b(T_r - T_c)$$

while the heat supplied to an equivalent turbine system by W_b pounds of live steam would be

$$W_b(H_s - T_r + 32)$$

The ratio of the cost per pound of bled steam to that

of live steam is therefore the ratio of these two amounts of heat, or

$$R_w = \frac{(W_t - W_n)(H_s - T_c + 32) - W_b(T_r - T_c)}{W_b(H_s - T_r + 32)}$$

in which we denote by R_w the ratio of the costs of producing bled to live steam per pound with condensate returned to boiler. This equation may be further reduced algebraically to

$$R_w = \frac{B(H_s - T_c + 32) - (T_r - T_c)}{(H_s - T_r + 32)}$$

It is seen that in cases where the condensate from the bled steam is not returned, the value of T_r is the same as the value of T_c and the relative cost of bled steam as found is the same as found by Mr. Fisher.

Since a pound of bled steam does not contain as much heat as a pound of live steam, it is frequently desirable to know the relative cost of doing an equal amount of heating with live, as against that for exhaust steam. The available heat in every case is that above the temperature T_r of the condensed steam returned, and if we assume the temperature to be the same with live and bled steam, the ratio of available heats of both will be

$$\frac{H_s - T_r + 32}{H_b - T_r + 32}$$

The relative cost of an equivalent amount of heat from bled and live steam, R_n, when condensate is returned, is then

$$R_n = R_w \frac{H_s - T_r + 32}{H_b - T_r + 32} = \frac{B(H_s - T_c + 32) - (T_r - T_c)}{H_b - T_r + 32}$$

When bleeding steam from a turbine the ratio of the weight of the steam which must be added at the throttle, is to the weight of steam bled, which we have denoted by B, as the ratio of the heat extracted from each pound of steam in the portion of the turbine between the point of bleeding and the condenser to the total heat extracted per pound by the entire turbine.

Let H_c = Heat extracted per pound of steam in passing through turbine to condenser;

H_f = Heat extracted per pound of steam in passing from throttle to point of bleeding.

The total heat extracted per pound in the turbine is given by the equation

$$H_c = \frac{3{,}415C}{WR}$$

in which WR is the water rate of the turbine under consideration and C is a constant factor which corrects for the outside turbine and generator losses. The value of C will vary from 1.08 in small units to 1.05 in large turbines.

The quantity of heat extracted per pound of steam in the portion of the turbine between the throttle and the point of bleeding, is

$$H_f = (1 - B)\left(\frac{3{,}415C}{WR}\right)$$

The heat content of the bled steam is then

$$H_b = H_s - (1 - B)\left(\frac{3{,}415C}{WR}\right)$$

Care should be taken not to confuse the use of the ratios R_w and R_n.

The use of the equations is shown in the following examples: In a certain plant supplying a heating load there is installed a 1,500-kw. turbine operating at 125 lb. gage, dry steam, discharging into a condenser under 2 in. abs. and bled after the first stage at 5 lb. gage. Under these conditions, when handling a load of 1,500 kw., the guaranteed rates are, H_s = 1,192.2 B.t.u.; W_n = 28,000 lb. per hr.; W_b = 40,000 lb. per hr.; W_t = 50,000 lb. per hr.; T_r = 180 deg. F.; T_c = 102 deg. F., and WR = 18.65 lb. per kw.-hr.

In calculating the performance values of this plant, these values were substituted in the equations and the ratio R_w was obtained as follows:

$$B = \frac{50{,}000 - 28{,}000}{40{,}000} = 0.55$$

$$R_w = \frac{0.55(1192.2 - 102 + 32) - (180 - 102)}{(1192.2 - 180 + 32)} = 0.514 = 51 \textit{ per cent}$$

$$H_b = 1192.2 - (1 - 0.55)\left(\frac{3{,}415 \times 1.08}{18.65}\right) = 1{,}103 \textit{ B.t.u. per lb.}$$

$$R_n = \frac{0.55(1192.2 - 102 + 32) - (180 - 102)}{(1{,}103 - 180 + 32)} = 0.564 = 56 \textit{ per cent.}$$

This series of calculations showed that the cost of producing bled steam was 51 per cent of the value of the live steam per pound and that on a basis of heating it was worth 56 per cent of the live steam. Heating by bled steam is therefore 5 per cent cheaper than by live steam. In any similar plant a series of readings can be taken and these same facts determined. When the actual conditions cannot be measured, the manufacturer's guarantees for the machinery can be obtained and used in connection with what readings are available.

C. E. COBORN.

Springdale, Pa.

Explosion of 20,000-Kw. Turbine at Shanghai

With reference to the article in the Dec. 25, 1923, issue describing the steam-turbine disaster at our Riverside Power Station, which occurred on Nov. 15, you mention the *North China Daily News* of Nov. 16 as the paper from which you obtained your information. The description in this paper is, like most technical descriptions of lay papers, somewhat colored and is not accurate in all its details.

In the main, however, the bursting of the turbine was, I think, unique in the history of turbine accidents, and at the present time investigations are being conducted with a view to determining the cause of the accident, therefore I am not in a position to make public opinions being formed. I should like, however, to correct a misstatement in the article to the effect that the steam was shut off owing to the presence of mind of one of the Chinese operators. This statement is in error, as the Chinese operator referred to was injured, and although he made the statement quoted to the press reporter, the facts are that the steam was shut off by two members of the European staff who were on duty in the boiler house. In fairness to them I wish to call attention to this misstatement.

At the conclusion of the description mention is made that the turbine was operated at 15,000 r.p.m. This, I presume, is a typographical error, as the operating speed was actually 1,500 r.p.m.

T. H. U. ALDRIDGE,
Engineer-in-Chief & Manager,
Shanghai Municipal Electricity Department.
Shanghai, China.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Use of Superheated Steam in Pipe Coil

For heating a liquid with a given pipe coil, can the same results be obtained if the coil is supplied with exhaust steam at atmospheric pressure and superheated to 338 deg. F. as by supplying the coil with saturated steam at 100 lb. gage pressure which would have the same temperature, or 338 deg. F.? C. B. G.

The same results could not be obtained with the superheated steam since for any heat loss from superheated steam there would be considerable reduction of the temperature of that part of the steam from which the heat is obtained; whereas, with saturated steam the water of condensation has the same temperature as that of the steam from which it is formed, and the temperature of the interior of the coil would remain the same as the temperature due to the pressure within the coil.

Poor Draft for New Boiler

We have recently placed a new 72-in. by 18-ft. horizontal return-tube alongside of two others of the same size connected to the old chimney connection, which always was sufficient for good draft when operating both of the old boilers; but we are troubled with back draft in the new boiler when only one of the old boilers is in use. The new boiler is connected to the smoke flue between the old boilers and the chimney. What can be done to insure the same draft for the new boiler as for the others? C. L. B.

The trouble may be due to not cutting off completely the draft of air from the old boiler that may not be in use. See that the dampers of the old boilers are closed tight when the boilers are not in use. Another cause for poor draft for the new boiler may be that the uptake connections are made square with the flue. If that is necessary, there should be a curved baffle plate in the flue for gradually changing the course of the gases toward the chimney before they are brought into contact with the gases from the other boilers. But if it is desired to retain the full draft capacity for the old boilers without obstruction of the flue by insertion of a baffle, the same effect would be obtained by connecting the uptake of the new boiler with the main smoke flue at an angle of about 45 degrees.

Jumping of Direct-Acting Steam Pump

We have a 6 x 4 x 6-in. duplex feed pump that makes a short jump of the pistons at the beginning of a stroke. How can this be prevented? R. M. S.

This is due to presence of air that has become liberated from the water during suction strokes and becomes lodged in pockets of the pump chamber or passages, often adhering to the surfaces so firmly that it cannot be removed except by heating or brushing off. Such films of air are repeatedly compressed and re-expand at every stroke, causing the pistons to begin strokes with a jump when the steam valves reverse. The trouble is more likely to occur with a high suction lift or contracted suction, or from allowing the pump to race when starting up. In a well-designed pump in which there are no pockets like air chambers, the air usually can be removed by warming the water end of the pump with steam from a hose and running the pump slowly for a while with the air vent on the top of the air chamber open and discharge line opened to the atmosphere at only a sufficient elevation to keep the pump chamber flooded.

Setting Slide Valve for Desired Cutoffs

How is a plain D slide valve set to obtain cutoffs at three-quarter stroke of the piston? W. T.

Remove the valve-chest cover and adjust the length of the valve stem so each end of the valve travels the same distance beyond the opening edge of its port for a complete revolution of the eccentric around the shaft, or if the eccentric is fast, for a complete revolution of both the shaft and eccentric. Make a mark on the crosshead and corresponding marks on the guide when the crank is at dead centers, and lay off points on the guide to represent the positions for the mark on the crosshead when the piston is at three-quarter stroke from each end. Then with the crosshead at three-quarter stroke from the head end, loosen the eccentric and turn it on the shaft in the direction of rotation of the engine until the steam port on the head end is just beginning to close. Tighten the eccentric and turn the engine until the crosshead has gone the required distance for cutoff from the crank end. Probably cutoff will not be found to come at this point. Now move the valve one-half the distance necessary to cause cutoff by changing the length of the valve stem and the other half by changing the position of the eccentric. Try the cutoff on the head end again, this time making one-half of any adjustment required by changing the length of the valve stem and one-half by resetting the eccentric on the shaft. Then if the adjustments have been made with care, both cutoffs will be at three-quarter stroke.

Simple Tests of Lubricating Oils

What simple tests can be made of lubricating oils to determine the presence of acids, tarry ingredients and animal oils? M. C.

From improper refinement of engine and machine oils there may be harmful presence of sulphuric acid, of which a properly refined lubricating oil should show no traces. Wash a sample of the oil with warm water.

Then test the water with neutral litmus paper. If even a faint reddish tint is shown on the paper, the oil should be rejected. A simple test may be made by partly immersing a piece of highly polished copper in the oil for twenty-four hours. If a trace of acid is present, the immersed surface of the copper will be made dull.

To test for tarry residues, dissolve in a test tube, 5 parts of oil in 95 parts of 86-deg. gravity gasoline. If the mixture is allowed to stand for an hour, tar and other insoluble matter will collect at the bottom of the test tube. A rough test for presence of animal oil may be made by heating about two ounces of the oil in a test tube with the same quantity of caustic soda, caustic potash or borax. Heat for about fifteen minutes, when the presence of animal oil will be shown by a light yellow deposit. A quick method of detecting the presence of animal oil is to place a few drops of the oil on the palm of the hand and rub it briskly with the other hand, when the heat produced will cause the characteristic odor of animal oil, if it is present.

Laying up Heating Boiler

How should a firebox boiler that is used for heating be laid up for the summer season? *E. F. C.*

The boiler should be cleaned by washing, and if it can be thoroughly dried out, the inside then can be kept from rusting by placing fresh unslaked lime in shallow pans in different parts of the boiler, using altogether about two quarts of lime per square foot of boiler grate, then closing the boiler up tight. With a firebox boiler it is difficult to dry out all water. If that cannot be done, it is better, after washing, to close the boiler up tight and refill with water to overflowing at the safety valve. Whichever method may be employed, the boiler and all connections should be thoroughly cleaned just prior to the time when use of the boiler is resumed. One objection to laying up a boiler filled with water is that the temperature then remains lower than if the boiler is dry and there is more exterior rusting from moisture condensed out of summer atmosphere. The best protection against rusting of this kind is to seal up the ashpit and firedoors and smoke connections, or other openings, so there will be as little circulation of air as possible over the boiler-heating surfaces.

Connecting Single-Phase Transformers on a Three-Phase Circuit

I wish to connect three single-phase transformers, each rated at 200 kva., 2,300 to 7,500 volts, in delta-star to step up for operation on a 13,200-volt three-phase system. Give a diagram of connections and the rules for finding the voltage and current. What load, in kilowatts, will the transformers be good for at 80 per cent power factor? With the three transformers connected delta-star, what will be the current at full load in the primary and secondary wires? *H. S. P.*

The figure shows how to connect the transformers. However, they will have a somewhat higher ratio than 2,300 to 7,500 in order to give 13,200 volts on the high-voltage side. As indicated on the diagram, with 2,300 volts on the low-voltage side only about 13,000 volts are obtained on the high-voltage side. The transformers are rated at 200 kva. so that on the low-voltage side the current per transformer will be 200 × 1,000 ÷ 2,300 = 87 amperes. This current is indicated on the diagram. The current per lead of three transformers connected delta on a three-phase system, and supplying a balance load, is equal to the current of one transformer times 1.732. Therefore, on the low-voltage side the current per lead at full load is equal to 87 × 1.732 = 150 amperes. On the high-voltage side the transformers are connected star, and with this connection the current per transformer is the same as the current per lead. The voltage between leads is equal to the voltage per transformer, times 1.732, or, in this case, 7,500 × 1.732 = 13,000. The kva. load equals volts × amperes × 1.732 ÷ 1,000; on the low-voltage side of the transformer, kva. = 2,300 × 150 × 1.732 ÷ 1,000 = 600; on the high-voltage side kva. = 13,000 × 26.7 × 1.732 ÷ 1,000 = 600. These figures are based on a transformer without losses, which are very small in any case on account of the high efficiency of the transformer.

Kilowatts equal kilovolt-amperes multiplied by power factor. Therefore, since the three transformers in question have a combined rating of 600 kva., at 80 per

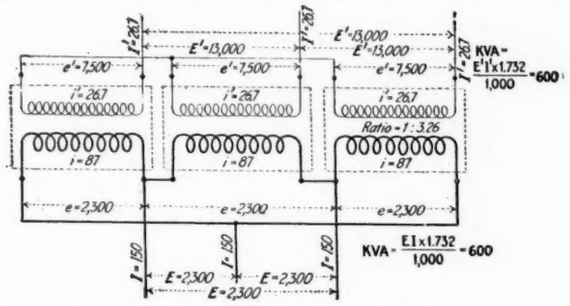


Diagram of three single-phase transformers connected delta-star

cent power factor they will be good for 600 × 0.80 = 480 kilowatts.

The power factor will not affect the full-load current of the transformer; that is, it will be the same at 80 per cent power factor as it is at unity power factor. At unity power factor the transformer is good for 600 kw.; at 80 per cent power factor it is good for only 480 kw.

The current in amperes per lead is equal to (kva. × 1,000) ÷ (volts × 1.732). For the transformers in question the kva. rating is 600; then the current per terminal on the low-voltage side is equal to (600 × 1,000) ÷ (2,300 × 1.732) = 150 amperes.

Heat Lost in Chimney Gases

If, in using coal containing 14,000 B.t.u. per pound, the flue-gas temperature was 450 deg. F. above the temperature of the boiler room and it is estimated that 25 lb. of air was supplied per pound of coal, what percentage of heat in the coal is lost in stack gases?

A. B. H.

The specific heat of chimney gases is about 0.24 B.t.u. per pound. Without allowing for the percentage of ash contained in the coal, the total weight of flue gas would be 26 lb. per pound of coal, and per pound of the gas, the heat content above the boiler-room temperature would be 26 × 450 × 0.24 = 2,808 B.t.u. Hence the percentage of heat lost in flue gases would be 2,808 × 100 ÷ 14,000 = 20 per cent of the heat in the coal.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Here and There in the Power Plant

Sidelights on things generally used but less generally understood

The Energy in Coal

STANDING in a country station while the limited sweeps through at a mile-a-minute pace, one gets the idea of tremendous energy. The imagination recoils from picturing the havoc that would result if this moving mass were suddenly brought to rest by a collision. Yet an equal amount of energy is contained in a single fair-sized scoop of coal. That this is true may be shown by a simple computation.

Suppose it is a modern passenger train consisting of locomotive, tender and ten steel cars. The cars should weigh about 70 tons each or 700 tons for the ten cars. Adding 150 tons for locomotive and tender, the total weight of the moving mass comes to 850 tons. Now the formula for the energy stored up in a moving mass is

$$E = \frac{M\ V^2}{64.4}$$

where E = energy in foot-pounds, M = mass in pounds and V = velocity in feet per second.

Then M is 2,000 × 850 = 1,700,000 lb. The velocity of one mile per minute is equal to 88 ft. per second, which is obtained by dividing the 5,280 ft. in one mile by the 60 seconds in one minute. Substituting these values in the formula we have

$$Energy = \frac{1{,}700{,}000 \times 88^2}{64.4} =$$

204,000,000 *ft.-lb.*

This and subsequent computations are carried only to three significant figures since extreme accuracy is a waste of time in making such comparisons.

One Scoopful Equals a Wreck

The next step is to express this amount of energy in heat units for comparison with coal. A single heat unit (B.t.u.) is equivalent to 778 ft.-lb., so the energy of the moving train expressed in heat units is 204,000,000 ÷ 778 = 262,000 B.t.u. Assuming a coal of 13,500 B.t.u. per pound, the weight of coal containing the same amount of energy would be 262,000 ÷ 13,500 = 19.4 lb.—not more than a single large scoopful.

It is quite true that, on account of running resistance and the low efficiency of the steam locomotive, many times this weight of coal would be required to bring the train up to speed, but the fact remains that the actual stored-up energy, ready to be released by a wreck, is that in one scoopful of coal.

The swiftly moving train seems more powerful to the imagination than the scoopful of coal because it will instantly release its energy upon any resisting body that falls in its path. The coal takes a little teasing and care and the presence of the right amount of oxygen. Then it gives up its energy, but at a leisurely rate under ordinary conditions.

To make another comparison, consider nitroglycerin, the dread explosive which the oil driller uses to "shoot" his wells and which is the explosive substance in dynamite. This, like the train, is the embodiment of terrific energy in the popular mind. Yet the chemists' figures show that here, too, coal is supreme as far as energy content is concerned. The energy in a pound of nitroglycerin is slightly under 1,900 B.t.u. About seven pounds of it would be required to equal one pound of coal on the basis of energy content. Here again the difference lies in the speed and ease with which the energy can be released. The nitroglycerin contains within its own molecules the material to support its "combustion." The whole affair is of a hair-trigger nature, ready to complete the chemical reaction in a fraction of a second if released by a small shock.

Coal as an Explosive

Nitroglycerin is an effective explosive for two reasons. First, it releases its energy almost instantaneously, so that it can exert an enormous force even though not closely confined. A more slowly generated pressure would leak out before it reached a sufficiently high value to be effective. The second reason for its effectiveness is that the material to support combustion is present in a dense form so that the substance possesses a great amount of energy per cubic inch of explosive mixture.

It is evident that the combustion of coal can never approach that of nitroglycerin in speed. The air to support combustion must be brought to it and burn it off gradually one layer at a time, working from the outside of each lump. To make an explosive of coal even comparable with gasoline vapor, for example, the coal must be in the form of a powder or dust, suspended in air. The speed of combustion depends on the amount of surface in contact with the air. It is evident that crushing increases this surface enormously.

When coal is crushed fine and suspended in air so that each particle of coal is surrounded by sufficient air for its combustion, the mixture becomes "explosive"; that is, if ignited at any point, the flame will flash through the whole mass almost instantly. This can do damage in two ways. In the first place the resulting temperature may be so high as to burn fatally any man in the space where the flash occurs. Secondly, the physical or mechanical damage may be great if the volume concerned is large. The actual pressure developed is not large, but totals an enormous force when spread over the hundreds of thousands of square inches in the wall of a large room.

Conditions Favoring Explosions

As is the case with gasoline mixtures, no explosion will take place until a certain weight of coal is present per cubic foot of air. The weight of coal present must be sufficient to produce a temperature above the ignition point of coal; otherwise the combustion cannot spread from the point of ignition. This necessary amount is, however, so small that any appreciably dusty atmosphere should be looked upon with suspicion. This statement applies to any inflammable material in dust form. For example, starch dust has been known to explode with great damage.

The explosibility of coal dust has been known for years, with the result that great precautions are taken in coal mines, and in cement mills using powdered coal, to avoid danger from this source. Powdered coal is perfectly safe if the proper precautions are taken to avoid the dust being wafted into the atmosphere of rooms or other large inclosed spaces. In this connection precautions must be taken against dust that has settled on floors, rafters, etc., being kicked up into an explosive mixture by a disturbance in some other part of the plant.

If powdered coal is sprinkled on the floor of a long tunnel and stirred up and ignited at one end, the local explosion will kick up the near-by dust, making an explosive mixture. The explosion of this in turn will kick up the next layer, so that a series of explosions will occur the whole length of the tunnel. Accidents of this sort can be avoided by preventing the accumulation of coal dust.

Comparison with Gasoline

In some respects coal may be compared with gasoline. People think of gasoline as an explosive. Yet as a liquid it cannot explode. To become explosive, it must be vaporized (or at least atomized) and mixed with air, the proportions being kept between certain limits. In this mixture each particle of gasoline has the air to burn it immediately at hand, so that combustion is almost instantaneous. The outstanding difference between the coal and the gasoline is that only the latter is volatile. The coal must first be crushed and mechanically mixed with the air for combustion. The gasoline is always ready to form its own mixture.

Modern Large Steam Turbines

IN a lecture before the Providence Engineering Society, Jan. 4, Linn Helander described conditions governing the design and operation of large steam turbines. For steam pressures above 400 lb. the use of the single-cylinder turbine in capacities above 35,000 kw. entails a serious sacrifice of

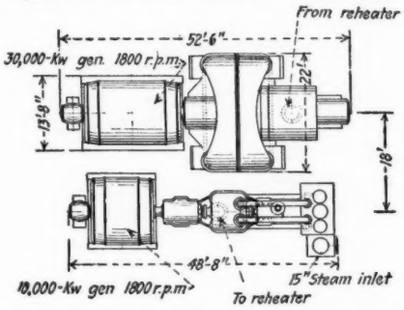


Fig. 1—Reheating cross-compound turbine, 600 lb. steam

efficiency, and compound units should be used.

For given steam conditions and a given cycle of expansion, the limitation of the capacity of the turbine is the area of the last row of blades through which the steam is discharged. If the capacity is increased without enlarging

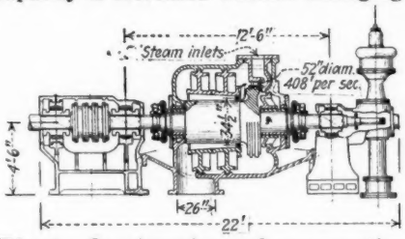


Fig. 2—One impulse and one reaction stage, 600 lb. steam

the area of the last row of blades, steam must escape through this area with added speed or velocity. This means that there will be greater losses, due to the velocity of the leaving steam which should have been turned into work. Besides being a measure of the capacity of the turbine, the discharge area of the last row of blades is also in a way the measure of the cost of the unit, since it determines about 60 per cent of the entire manufacturing cost.

High-Temperature Uncertainties Limited to High-Pressure Turbine

Higher steam pressures introduce uncertainties in regard to temperatures and stresses. By the use of cross-compound units these uncertainties are confined to a high-pressure unit. The margin of safety in the usual design of the other units at ordinary pressures is thus safeguarded. The floor space required for large cross-compound units is no larger than that required by single-shell units, since the floor space in a properly planned station is usually determined by the condenser and its auxiliaries. Alignment problems are simpler in a cross-compound unit, and there is less danger of transmitting irregularities of operation from one element to the other.

With the use of higher steam pressures, reheating of the steam at a

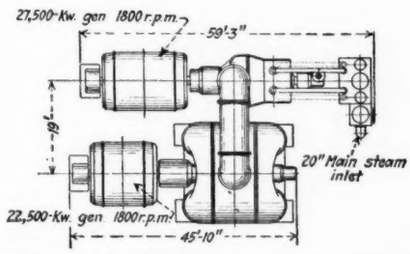


Fig. 3—50,000-kw. cross-compound turbine, 300 to 400 lb. steam

lower pressure, and then supplying it in a reheated condition for the remainder of the expansion, becomes more necessary. With one reheating point the greatest gain is usually obtained by reheating at a pressure that represents one-third of the adiabatic heat drop, or in other words, reheating after

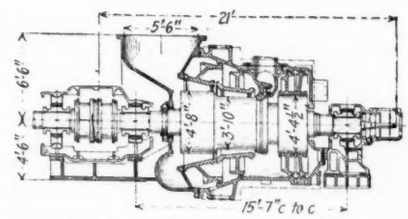


Fig. 4—Impulse-velocity, high-pressure unit, 400 lb.

one-third of the total work in the turbine is done. This determines the exhaust pressure of the high-pressure element, where steam enters the reheater.

A 50,000-kw. cross-compound unit for 600 lb. steam would ordinarily be designed with the high-pressure element to carry 10,000 kw. at 1,800 r.p.m. The low-pressure element would operate at the same speed, and is indicated in Fig. 1. The high-pressure element in Fig. 2 contains an impulse velocity-stage turbine with two rows of blades. The steam then travels through reaction vanes held by two blade rings. The low-pressure element would be represented in Fig. 5, except that the velocity stage at the high-pressure end would not be utilized.

Triple Expansion Cross-Compound Turbine for 1,200 Lb.

A 40,000-kw. cross-compound unit designed to operate at a steam pressure of 1,200 lb. would probably have a high-pressure element at much higher speed, in order to maintain physical dimensions that are reasonable, and to insure high efficiency. Figs. 3 and 4 indicate cross-compound units of 50,000 to 60,000 kw. for steam at 300 to 400 lb. pressure. In case of higher pressures, such as 1,200 or 1,500 lb., here would be an additional high-pressure unit, making three units in all of the complete cross-compound machine. With steam entering the intermediate element at 300 lb. an impulse wheel would be used, as illustrated in Fig. 4. For entering steam of 130 lb., however, the impulse blades would be removed, while for 180 lb. of entering steam a single-row impulse wheel would be present, in addition to reaction vanes.

On the reheating cycle, a large volume of steam is stored in the reheating system. Provision must therefore be made to prevent excessive overspeeding in case the load were taken off and the main valve to the high-pressure unit closed. The emergency governor should operate a butterfly valve in the heating system, and also a relief valve, so that the steam could be cut off from the lower pressure unit and exhausted directly into the condenser.

Higher Pressures and Reheating Increase Capacity

The use of higher steam pressures together with the extraction of steam for heating the condensate makes it possible to provide increased capacity, relatively speaking. For the same capacity of turbine a smaller area for the

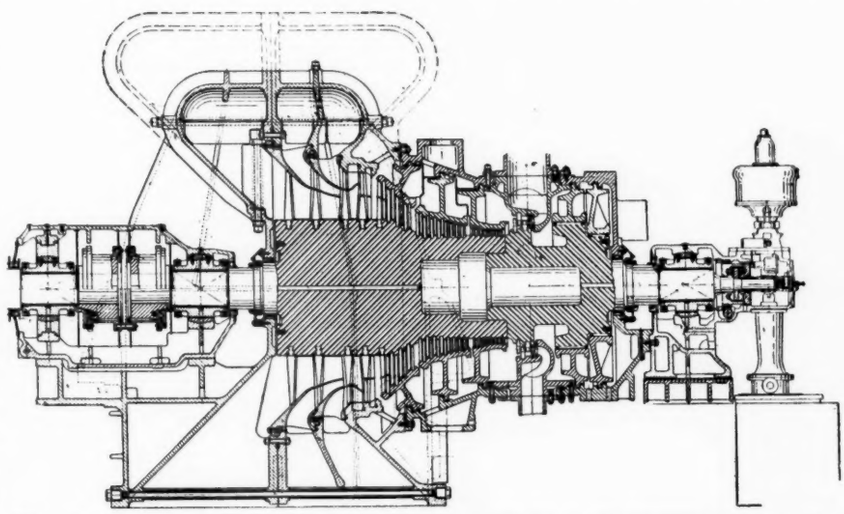


Fig. 5—Velocity stage is removed when used as a low-pressure element

exhaust blading would be required, or with the constant area of exhaust blading the capacity of the turbine could be increased by slightly increasing the high-pressure blade passages.

The manufacture of large turbines entails the use of expensive patterns, tools and dies. These cannot be frequently changed without making the cost of the turbine prohibitive. Turbine designers therefore endeavor to anticipate only those developments that are likely to achieve a broad prominent acceptance. Deviation from standard design can be made only at large expense, which should be borne by the purchaser. This increases the fixed charges against the cost of power. Power-plant engineers making new station layouts will go far toward assuring the commercial practicability of this design by interchanging ideas with the turbine manufacturer. This usually proves mutually beneficial, particularly as the principles underlying modern steam power-plant heat-balance design are well understood by the turbine designer.

High-Pressure Developments Outlined by Eskil Berg

STEAM pressures around 550 lb. for new central stations were recommended as a reasonable choice in the present state of the art by Eskil Berg, of the General Electric Co., in a lecture delivered before the Franklin Institute in Philadelphia on March 19. It was suggested that the 1,200-lb. pressure to be used in two American stations at an early date would doubtless result in a considerable improvement in efficiences and that general practice in large plants might gradually rise to the neighborhood of 1,000 lb. in the course of the next four or five years. The following digest covers the main points of Mr. Berg's address and the discussion that followed:

Many high-pressure plants are now under construction or consideration. The American Gas and Electric Co. has three projects of this sort, one plant with four 35,000-kw. units and the others each having two 35,000-kw. units. In each case steam will be generated at 600 lb. and 725 deg. and reheating at 100 lb. will be employed. The Columbia Gas & Electric Co. will install two 40,000-kw. units and the Chicago (Commonwealth) Edison Co. two 50,000-kw. units and one 60,000-kw. unit, all to operate under the conditions just mentioned. It is generally known that 1,200-lb. installations are under way in the Weymouth and Calumet stations.

Activity in Turbine Manufacture

The enormous activity in the power industry may be judged from the fact that a single manufacturer of turbines has under construction 58 units ranging from 20,000 to 60,000 kw. capacity. Most of these are 35,000-kw. units. When it is considered that it required approximately $1,000,000 a year in fuel to operate a single unit of this size continuously at full load, the importance of obtaining the utmost efficiency is evident. By taking full advantage of increased pressures and superheat with reheating and bleeder feed heating, the fuel consumption can be reduced 25 per cent, a saving of about $250,000 a year for a single unit. This saving must come mainly from higher pressures and more economical cycles, since turbine design is already perfected to the point where most of the available heat is utilized. The very best central stations now generate a kilowatt-hour for about 17,000 B.t.u., corresponding to an over-all thermal efficiency of 20 per cent Of the remaining energy in the fuel about 20 per cent is lost in the boiler room, 55 per cent in the circulating water and 5 per cent in other ways.

Not long ago 14 to 15 lb. per kilowatt-hour was considered a reasonable steam rate. The latest advances reduce this to 7 lb., which cuts in half the condenser loss. The size of the condenser is correspondingly reduced. Starting at 200 lb. absolute, the net theoretical fuel saving due to increased pressure alone (with 28.5 in. vacuum and saturated steam) is as shown in Table I.

TABLE I—EFFECT OF PRESSURE ON FUEL CONSUMPTION

Absolute Pressure, Lb. per Sq. In.	Net Gain in Per Cent
200	—
300	7.44
400	11.62
500	14.43
600	17.09
700	18.79
800	20.54
900	21.51
1,000	22.60

In practice the gain would be much less, because the average percentage of moisture in the expanding steam would increase rapidly with the pressure. The presence of moisture causes friction and reduces the turbine efficiency. Moisture is particularly serious in the high-pressure stages due to the greater steam density. The theoretical advantage of superheat is small, but the practical advantage is about three times as great because of the reduction of the friction loss due to wet steam. For example, the practical over-all plant gain from 300 deg. superheat is about 10.5 per cent, although the theoretical is but 2.8 per cent.

One Pound per Kilowatt-Hour Within Reach

Comparisons of various pressures should be made on the basis of a fixed total temperature rather than a fixed superheat. Such curves flatten out considerably around 1,000 lb. Bleeder heating increases the pressures that are commercially economical. For a single stage of reheating the best reheat pressure is theoretically about one-third the initial, but practically about one-fifth.

With a 50-000-kw. unit, 1,800 r.p.m., 350 lb., 725 deg. and 29-in. vacuum, a thermal efficiency of 29.54 per cent may be obtained without reheating. At 550 lb. (other conditions the same) this increases to 31.32 per cent and with reheating to 33.09 per cent.

Allowing for boiler losses, this means that a kilowatt-hour can be obtained for 13,000 to 14,000 B.t.u., representing one pound of coal. The best present-day stations take about 1.3 lb. The Boston Edison is expecting to get 0.94 lb. with its 1,200-lb. installation and may do even better. This will put the large steam plant in the same class as the Diesel engine as far as efficiency is concerned.

In the discussion slides were shown of the 1,200-lb. boiler at Weymouth (similar to that described in the May 29, 1923, issue of *Power*). Photographs were shown picturing the forging of the drums from a solid piece of steel. The finished drum was given a hydrostatic test at 4,000 lb. per sq.in.

Mr. Berg showed how high pressure and bleeding helped the turbine designer. The last stage leaving losses limit the size of the turbine. For a given leaving loss the higher pressure permits a 25-per cent increase in capacity, extraction another 25 per cent and reheating a 20-per cent increase, the combined effect being that the turbine capacity can be increased 78 per cent without increasing the last-stage loss. Larger machines mean a smaller percentage loss in friction and hence an increased efficiency.

Does Not Increase Investment

Replying to a question on the economic side, Mr. Berg said that the high-pressure plant should cost no more, the slightly greater cost of the turbine being counterbalanced by reduced cost of the condenser and possibly also of the boiler. These reductions are due to the smaller capacity made possible by the increased thermal efficiency and reduced water rate of the turbine. A representative of the boiler manufacturers corroborated the statement concerning the cost of the boiler. The boiler admittedly costs more per square foot, chiefly on account of the forged drum, but smaller size prevents an increase in the cost per kilowatt capacity.

Mr. Berg disapproved of the use of economizers in the 1,200-lb. installations, suggesting that stage heating and air preheaters would make a better combination. It seemed to be generally agreed that installations around 1,000 lb. would not come into general use for at least four or five years. This would give the necessary time for working out the operating problems and insuring the necessary reliability for general commercial application.

The installed horsepower of hydraulic turbines in Canada has increased from 1,446,000 in 1912, to 2,970,000 in 1922, or by 105 per cent in 10 years. The effect on coal consumption is strikingly illustrated by the official coal statistics, which show that in spite of increase of population and far more than proportionate increase in manufacturing industry, the total coal consumption in 1922 was less than in 1913—the actual figures are: For 1913, 31.6 million tons; for 1922, 31.3 million tons.

Federal Power Commission Officials Against Bolder Canyon Dam Site

Governor Hunt of Arizona Accuses Officials of Favoring Colorado and California

IN THE report which Col. William Kelly, the chief engineer of the Federal Power Commission, submitted to the Secretary of the Interior in connection with the unanimous report made by the advisory committee, he makes the point that the information now at hand is not sufficient to justify the absolute selection of the site proposed by the Bureau of Reclamation, for a dam in Boulder Canyon. It is his belief that with the expenditure of less than $100,000 it would be possible to put down enough holes to determine if it will not be possible to get out of the narrow and inaccessible part of the canyon in the finding of a dam site. He believes the Mohave site is by far better than the one chosen by the Reclamation Bureau in Boulder Canyon. "If the Mohave site proves impracticable," says Colonel Kelly, in his report, "further investigation of Black Canyon and Boulder Canyon should be made to determine the best location for the dam, taking into consideration the fact that it should provide only 4,000,000 acre-ft. of flood storage and should be adjusted as to height to fit into the full scheme of development of the river without unnecessary loss of head."

At another point in his report Colonel Kelly draws these conclusions:

"The final development of the river is almost certain to make Boulder Canyon a power development and not a storage reservoir. If Boulder Canyon dam be built to the height recommended by the Bureau of Reclamation, evaporation losses in excess of those for dams of lesser height built to fit the ultimate development, will amount to from 300,000 to 450,000 acre-ft. per year. Furthermore, the 605-ft. dam recommended will involve a loss of head, in the Canyon section of at least 80 ft., which represents an ultimate loss of 75,000 horsepower.

In their capacities as members of the Federal Power Commission the Secretaries of War, Interior and Agriculture have subscribed to a letter in which they disapprove of the Swing-Johnson bill and call strikingly to the attention of Congress where a general policy of federal development of electrical energy will lead.

According to press reports Governor Hunt of Arizona, in a letter to the committee, made such strong accusations against the good faith of the officials and representatives from Colorado and California that a summons to appear before the committee was mailed to him. Carl Hayden, Representative from Arizona, stated, however, that the intense attitude of Governor Hunt did not represent the stand of the state as a whole, and that he believes that the compact should be ratified.

View down Colorado River from north side of river just below upper Boulder Canyon Dam site

Research Laboratory Seeks Endowment

In accordance with plans made at the annual convention steps are now under way for procuring an endowment for the Research Laboratory of the American Society of Heating and Ventilating Engineers, which will insure its operation on a permanent basis. The actual drive for funds for such an endowment will probably be placed in the hands of some organization that makes a business of drives.

A.S.M.E. Boiler Code Adopted by State of Washington

Another state, Washington, has been added to the list of those that have adopted the A.S.M.E. Boiler Code. The laws are contained in the Safety Standards Pamphlet of the Department of Labor and Industry, Edward Clifford, director and H. L. Hughes, supervisor of safety compliance. The laws became effective on Jan. 1 and are compulsory in accordance with the provisions of the Industrial Insurance and State Safety Laws.

The Boiler Codes of 1918 and 1921 additions for Locomotive Boilers of the A.S.M.E. are approved by this department. Boiler inspections made by inspectors employed by insurance companies licensed to write boiler insurance in this state and also inspections made by city boiler inspectors or other boiler inspectors of competence will be accepted.

Grouping of Public Works Disapproved by Committee

A reorganization bill is being whipped into final shape by the Congressional committee that has had under consideration proposed changes in the grouping of federal bureaus and the proposed reassignment of some of the duties of bureaus.

It is understood that the committee has decided to make no transfer of river and harbor work. This is taken to mean that the committee has disapproved the plan of grouping public works functions in the Interior Department.

In deciding to leave the river and harbor work in the Corps of Engineers of the War Department, the committee is thought to have been influenced by the belief that Army officers are in a better position to resist the strong pressure brought by communities and other proponents of river and harbor improvements than civilian employees.

Bill To Amend Water Power Act Before Congress

Power to Employ Personnel—Sole Authority for Issuing Licenses—Power Over Licenses Granted Before Act—Moneys Collected To Reimburse Costs—Restore to Entry Lands Without Power

FIVE amendments to the water power act are proposed in a bill that has been introduced in the Upper House of Congress by Senator Jones, the chairman of the Committee on Commerce—the committee having jurisdiction over water-power legislation.

These amendments provide that the Commission may employ its own personnel rather than borrow employees from the War, Interior and Agricultural Departments, who are paid out of the appropriations of those departments. The second amendment provides for placing in the Commission the sole authority to issue licenses for power developments and to conduct investigations with respect to them. The third amendment would empower the commission to take jurisdiction over permits and licenses issued under legislation prior to the passage of the water power act. The fourth amendment proposed would make available for administrative expenses the actual money collected for that purpose. The fifth amendment makes provision for a more complete utilization of lands withdrawn as power-site reserves.

The bill was introduced at the request of the Federal Power Commission. Secretaries Weeks, Work and Wallace have joined in a statement as to the need of these amendments. In connection with the statement as to the proposed amendments the three Secretaries review briefly the results accomplished since the enactment of the water power act. In that connection, they say:

"In the three and one-half years that the federal water power act has been in force, there have been filed with the commission nearly 500 applications for power projects, involving an estimated installation, when constructed, of 21,500,000 hp., or more than twice the total installed horsepower in existing water-power plants of all kinds in the United States. The commission has issued permits and licenses for 7,500,000 hp., five times as much as had been granted under Federal authority prior to the passage of the act. There are 2,400,000 hp. built or building under license of the commission, or nearly twice as much as was built under previous Federal legislation in our whole history. The commission has made disposition of 75 per cent of the applications filed. The majority of those—in terms of horsepower—which have not yet been acted upon, involve the Colorado and Columbia Rivers and Canadian boundary waters.

Power Station for British Empire Exhibition

In order to provide a large amount of the power for the British Empire Exhibition which is to be held in Wembley, near London, this summer, a station is being erected in the Palace of Engineering, which is to include machinery supplied by the British Electrical and Allied Manufacturers Association and the British Engineers' Association. Up to the present time the demand has aggregated about 10,000 kw. for lighting, amusements, exhibitors, etc., as described in the March 7 issue of *The Engineer.*

The main power station will supply alternating current from three turbo-generators of 4,500 kw. total capacity. A large substation will supply 2,000 kw. of alternating current. Direct-current units in the main power house will represent a capacity of 1,000 kw., giving 7,500 kw. from these sources. Several smaller substations will assist.

The direct-current plant consists of a tandem horizontal Paxman-Lentz steam engine at 130 r.p.m. with a 300-kw. generator. A twin type Blackstone crude-oil engine drives a 180-kw. generator. A 4-cylinder vertical cold starting Ruxton-Hornsby oil engine drives another direct-current generator. A semi-stationary combined boiler and engine installation, which includes the condensing plant and water cooler, drives a 175-kw. generator.

Three 1,500-kw. turbo-generators are furnished by the British Thomson-Houston Co., the English Electric Co. and James Howden-General Electric Co.

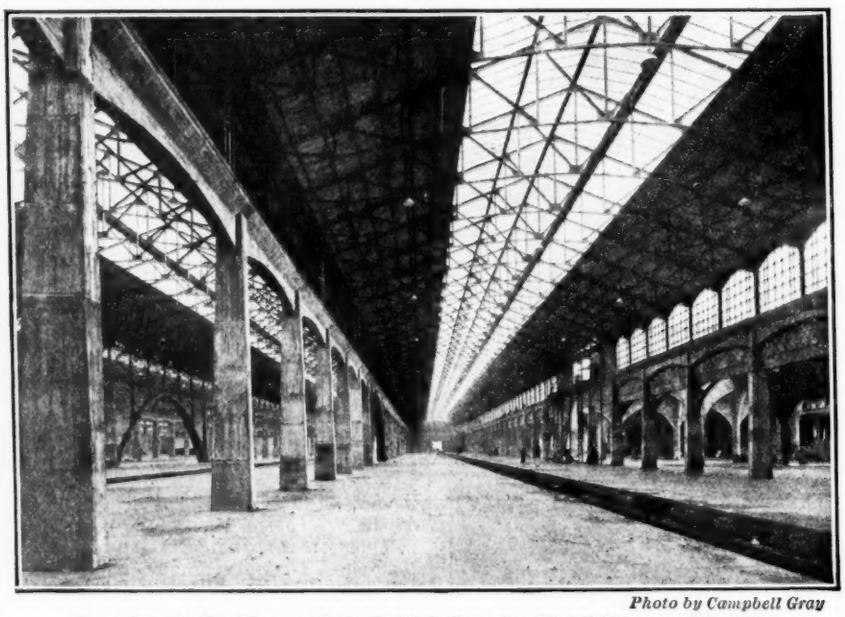


Photo by Campbell Gray

Interior of Machinery Hall, British Empire Exhibition at Wembley

Amendment to Conservation Act of N. Y. Offered

A bill has been introduced into the New York Senate amending the conservation law, Sec. 621 of Chapter 47, 1911, so that any regulation undertaken by the state authorities may not have jurisdiction over municipal corporation water-power licenses. It would exempt municipalities from the provisions applying to private corporations both as to rates and as to supervision by the Public Service Commission. The amendment is aimed to protect municipalities that now have power developments or may wish them, from the possibilities of a general policy of state power development nullifying the right now possessed.

Consumers Careless in Regard to Coal Storage

Coal consumers apparently began to use their stocks immediately on learning that the Jacksonville agreement had been signed. The production statistics and other information reaching the federal agencies concerned with coal indicate that the policy being followed very generally is to curtail coal purchases or new commitments to make as large use as possible of these reserves.

Officials who are watching the trends in the coal trade are fearful that consumers are backsliding, if any of them were really converted to the storage idea last year. The thought in official circles is that purchases of coal should continue at a rate that will retain intact the greater part of the reserves now on hand. These stocks are old enough so that the possibilities of spontaneous combustion have been reduced greatly. For that reason alone, in the case of certain coals, the retention of the reserve piles would be justified. If a generous reserve is carried until the crop movement begins this fall, not only will a public service be done, but the worries and losses incident to an uncertain coal supply will be avoided. It is very apparent that should the present trend go on unhalted the railroads will be called upon this fall to handle a high peak of coal movement at a time when they will be less able than ever before to handle such a contingency.

Preliminary Technical Program of the A.S.M.E.

The Spring meeting of the American Society of Mechanical Engineers, which is to be held in Cleveland, Ohio, May 26-29, will hold, on the morning of May 28, a joint session with the American Society for Testing Materials on "Properties of Materials at High and Low Temperatures." There will also be held a joint session with the American Society of Refrigerating Engineers which meets in Cleveland May 27-29. The preliminary technical program of the A.S.M.E. of interest to *Power* readers is as follows:

Session on "Mercury Vapor Process," with paper by W. L. R. Emmet.

Conference on Industrial Education under the auspices of the A.S.M.E. on "Education and Training in the Industries."

Power Problems of Steel Industry (Gas, Power and Power Divisions): "General Power Problems," by Bryant Bannister; "Steam Problems," by John A. Hunter; "Gas Power Problems—Use of Gas Engine in Steel Works," by A. E. Danks.

General Session on Windmill and Fan Design: "Performance of Centrifugal Fans for Electrical Machinery," by C. J. Fechheimer; "Wind Power," by F. J. Pancratz.

Cleveland Power Session: "Pulverized Fuel," by Mr. Aldrich; "High-Pressure Pumping," by L. A. Quayle; "Determination of Heat Losses Through Insulating Material," by R. H. Heilman.

Public Hearing on Power Test Codes —Condensers and Gas Producers.

Topical Discussion on Materials at High and Low Temperatures (joint session with the A.S.T.M.): "Industrial Application of Metals at Various Temperatures," by L. W. Spring; "Methods of Testing at Various Temperatures and Their Limitations," by V. T. Malcolm.

Joint Session with the A.S.R.E.: "Temperature Measurement," by P. Nicholls; "Heat Transfer," by Edgar Buckingham.

Heat Transfer Program of American Chemical Society

The heat transfer symposium planned by the Section of Industrial and Engineering Chemistry to be held in connection with the spring meeting of the American Chemical Society at Washington, D. C., April 21-25, includes:

"Evaporator Scale Formation," by W. L. McCabe and C. S. Robinson, of the Massachusetts Institute of Technology; "Forced Convection of Heat in Gases and Liquids, II," by C. W. Rice, General Electric Co.; "The Film Concept of Heat Transmission Applied to a Commercial Water Heater," by D. K. Dean, Alberger Pump & Condenser Co.; "Characteristics of Air Blast Heaters," by F. R. Ellis and J. D. White, B. F. Sturtevant Co.; "Heat Transfer from Bare and Insulated Pipes," by R. H. Heilman, Melon Institute of Industrial Research; "Loss of Heat from Furnace Walls," by R. Calvert and Lyle Caldwell, The Celite Co.; "Optimum Operating Conditions for Pipe Heating and Cooling Equipment," by W. K. Lewis, J. T. Ward and E. Voss, Massachusetts Institute of Technology; "A Heat Meter," by Percy Nichols, Research Laboratory, A.S.H.V.E.; "Heat Losses from Various Shapes," by L. B. McMillan, Johns-Manville Co.; "Evaporator Design," by W. L. Badger, University of Michigan.

Russian Engineers Form New Society

The Association of Russian Engineers is the name of a society recently organized according to the laws of New York State, which is to be devoted to the study of engineering progress in this country, as well as to informing the membership of the engineering profession in America with the progress of Russian technique. The first meeting of the new society, which is open to members and guests of all engineering societies, is to be held in the Engineering Societies Building, 33 West 39th St., New York City, at 8 p.m. on May 2. The program will be: "The Value and Aim of Scientific Management," by Frank B. Gilbreth; "The Progress of the Scientific Management Movement in Russia," by Walter N. Polakov.

Coolidge Appoints Oil Conservation Board

PRESIDENT COOLIDGE has appointed a commission to investigate the oil reserves of the nation. As much fear has been expressed that unless some such measure was taken, an adequate supply of fuel oil for the Navy, both for its permanent needs and for an emergency in case of war, would not be available when needed, this step should meet with universal approval.

George Otis Smith, Director of the Geological Survey, Admiral Jones, Commander-in-Chief of the United States Fleet, and A. D. Bush, of the California Bureau of Mineralogy, are the men named by the President to be members of this commission.

The Commission will be expected to investigate the question of how much oil in the existing naval reserves can be conserved underground and how much of it, if it is to be saved at all, must be at once got out and put in storage, and to report on ways and means of better defining the boundaries of naval oil reserves and of providing new ones in Alaska and elsewhere.

Remarkable Test Results at Hell Gate

Over-all boiler efficiencies (including economizer) as high as 92.7 per cent were recently obtained at the Hell Gate Station, according to tests made public at a meeting of the Metropolitan Section of the A.S.M.E. on March 25. The boiler, which was developed by Thomas E. Murray, consulting engineer, New York City, has side walls practically free from brickwork above the fire level. These walls are constructed of vertical tubes with welded fins filling the space between, so that a continuous metal surface is exposed to the radiant heat of the fire. The test in which the efficiency just quoted was obtained showed an efficiency without economizer of 84.6 per cent. This was at 181 per cent of rating. In a short test for capacity only, 528 per cent of rating was maintained for three-quarters of an hour.

In the first of the papers presented before the audience of 500 at the Engineering Societies Building, E. B. Ricketts, of the New York Edison Co., discussed the problems of the furnace designs, with particular reference to refractories, air heaters and the problem of mixing the gases from underfeed stokers.

Thomas E. Murray then submitted a paper describing the development of the new type of furnace at the Hell Gate and Sherman Creek plants. Following this W. E. Caldwell, test engineer with the United Electric Light & Power Co., described the tests and the startling results obtained. Comprehensive abstracts of these papers will appear in early issues.

A short address was delivered by Dr. G. Klingenberg, president of the V. D. I. (Society of German Engineers). Dr. Klingenberg outlined the information brought out in the "high-pressure" meeting of the V. D. I., a report of which appeared in the March 25 issue of *Power*.

John W. Lieb, New York Edison Co., complimented the authors of the papers on their valuable contributions to engineering progress.

Personal Mention

H. W. Bromley, formerly superintendent of power of the Pennsylvania-Ohio Electric Co. and associated with the company for ten years, with headquarters in Youngstown, Ohio, has resigned.

Dr. Van H. Manning, who has been director of research of the American Petroleum Institute during the past three years, has resigned to accept a position with the Pan-American Petroleum & Transport Co.

Frederick Pope and **Alva O. Greist** have become associated as consulting and designing engineers, specializing in chemical, power and public utility work. The offices of the new organization are at 280 Madison Ave., New York City.

Herr Prof. Dr. Ing. G. Klingenberg, president of the Verein Deutscher Ingenieure, Deutscher Verband Technisch-wissenschaftlicher Verein and Director of the Allgemeine Electricitaets Gesellschaft, accompanied by his wife, is making a visit to America.

F. W. Lass, for several years superintendent of power for the Iowa Railway & Light Co., Cedar Rapids, and for the last six years associated with the Doherty properties at Denver, Colo., has been appointed chief engineer of the new plant at Valmont, Colo., the hydroelectric plant of the Public Service Co.

H. G. Harper has been appointed chief engineer of the Kenova, W. Va., station of the Consolidated Power & Light Co., succeeding Charles H. Lake, recently deceased.

Fred J. Miller, of Center Bridge, Pa., past president of the A.S.M.E., has been appointed a member of the Public Service Commission by Governor Pinchot of Pennsylvania.

A. O. Berry has recently opened an office at 330 Market St., Chattanooga, Tenn., for consulting practice in general mechanical engineering, including boiler testing, combustion, fuel economy and coal analysis.

Karl A. Lefren, formerly chief engineer of the Robert Gair Co., has opened a consulting engineering office at 171 Madison Ave., New York City, where he will practice engineering in connection with power, paper mills and general mill construction.

Frank H. Martin, since 1921 chief engineer for the Manitoba Power Co., and identified with many hydro-electric projects in Canada and elsewhere has opened a consulting engineer's office at Winnipeg. He is still retained in an advisory capacity by the Manitoba Power Co.

Obituary

Henry J. Horstmann, of the F. W. Horstmann Co., manufacturing engineers, of Court St., Irvington, died suddenly of a heart attack at his home 240 Ridge St., Newark, N. J., on March 20. Mr. Horstmann was born in Newark fifty-seven years ago and had lived there most of his life. Surviving are his widow and several brothers and sisters.

H. D. Megary, managing director of the Consolidated Pneumatic Tool Co., London, England, died there suddenly on March 20, of septic poisoning. Mr. Megary was born in Philadelphia in 1888 and attended school in that city, graduating from the University of Pennsylvania in 1909. Following his graduation he became affiliated with the Bethlehem Steel Co., remaining with it until 1918, when he joined the Chicago Pneumatic Tool Co. as assistant to the president, later being made secretary of the company. In 1921 he was transferred to London to assume the duties of managing director of the English company. His death came as a great shock to his friends and associates.

Society Affairs

The Philadelphia Section of the A.S.M.E. will have as the subject of its April 22 meeting "Relative Performance of Steam and Diesel Engine Driven Ships."

The Waterbury Section of the A.S.M.E. will devote its April 26 meeting to an excursion to the new power plant of the Connecticut Light & Power Co. at Devon, Conn.

The Chicago Section of the Association of Iron and Steel Electrical Engineers will hear G. R. McDermott, of the Illinois Steel Co., on "Combustion," at its April 18 meting.

Coming Conventions

American Chemical Society. Charles L. Parsons, 1709 G St. N.W., Washington, D. C. Annual meeting at Washington, D. C., April 21-25.

American Electrochemical Society. C. G. Fink, Columbia University, New York City. Meeting at Hotel Bellevue-Stratford, Philadelphia, Pa., April 24-26.

American Institute of Electrical Engineers. F. L. Hutchinson, 29 West 39th St., New York City. Spring convention at Birmingham, Ala., April 7-10.

American Order of Steam Engineers. W. S. Wetzler, 753 North 44 St., Philadelphia, Pa. Annual meeting at Moose Hall, 1314 North Broad St., Philadelphia, Pa. June 2-7.

American Society of Civil Engineers. John H. Dunlap, 29 West 39th St., New York City. Spring meeting at Atlanta, Ga., April 9-12.

American Society of Mechanical Engineers, Calvin W. Rice, 29 West 39th St., New York City. Spring meeting at Cleveland, Ohio, May 26-29.

American Society of Refrigerating Engineers. W. H. Ross, 35 Warren St., New York City. Annual meeting at Cleveland, Ohio, May 27-29.

American Water Works Association. J. M. Diven, 153 West 71st St., New York City. Annual convention at New York City, May 19-21.

American Welding Society, Miss M. M. Kelly, 29 West 39th St., New York City. Annual meeting at New York City, April 23-25.

Electric Power Club. S. N. Clarkson, Keith Bldg., Cleveland, Ohio. Meeting at Seaview Golf Club, Absecon, N. J., May 26-29.

International Railway Fuel Association. J. B. Hutchinson, 6000 Michigan Ave., Chicago. Annual convention at Hotel Sherman, Chicago, Ill., May 26-29.

Master Boiler Makers Association. H. D. Vought, 26 Cortlandt St., New York City. Meeting at Chicago, May 20-23, 1924.

National Association of Stationary Engineers. Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual convention and exhibition at Hotel Pantlind, Grand Rapids, Mich., Sept. 8-13. Annual conventions and exhibitions of the state associations are scheduled as follows: **Kansas Association** at Parsons, Kans., April 16-18. J. M. VanSant, 739 Horne St., Topeka, Kan. **Indiana Association** at Lafayette, Ind., May 5-6. Prof. A. W. Cole, Purdue University, Lafayette, Ind. **New Jersey Association** at Newark, June 6-8. Joseph P. Flynn, 612 Franklin St., Elizabeth, N. J. **Iowa Association** at Sioux City, June 10-14. Abner Davis, 16 Waterhouse Block, Cedar Rapids, Iowa. **Ohio Association** at Akron, June 19-21. T. S. Garrett, 2622 East Second St., Dayton, Ohio.

National District Heating Association, D. L. Gaskill, 112 West Fourth St., Greenville, Ohio. Annual convention at New York City, June 10-12, 1924, formerly announced June 11-14.

National Electric Light Association. M. H. Aylesworth, 29 West 39th St. New York City. Annual convention at Atlantic City, Young's Million-Dollar Pier, May 19-24. **Nebraska Section,** H. M. Davis, Banker's Life Bldg., Lincoln, Neb. Sectional meeting at Omaha, May 8-9. **Southwestern Division,** S. J. Ballinger, San Antonio Public Service Co., San Antonio, Texas. Divisional meeting at New Orleans, April 22-25.

Society of Industrial Engineers. George C. Dent, 608 South Dearborn St., Chicago, Ill. Eleventh annual convention at Hotel Statler, Buffalo, N. Y., April 30 to May 2, 1924.

World Power Conference. O. C. Merrill, Federal Power Commission, Washington, D. C. British Empire Exhibition, Wembley, London, June 30-July 12.

The British Association for the Advancement of Science will hold its annual meeting this year in Toronto, Canada, Aug. 6-13.

The Metropolitan Section of the A.S.M.E. and the **Student Branches** will hold a joint convention on April 30. The Commissioner of Plant and Structures of New York City has placed a municipal ferryboat at the disposal of the students, so that they may be enabled to visit the power plants in the vicinity of New York. The evening session will be devoted to a symposium on "Combustion Control."

Business Notes

The Cleveland Worm & Gear Co., Cleveland, Ohio, announces that Howard Dingle is now vice-president and general manager as well as a director of the company.

The Ideal Commutator Dresser Co., formerly at 5353 N. Western Ave., Chicago, Ill., has moved into its new factory at Sycamore, Ill., just on the outskirts of Chicago.

The McMyler-Interstate Co., Cleveland, Ohio, announces the opening of a new branch office at 619 Genesee Bldg., Buffalo, N. Y., which will be in the charge of J. E. McFate.

The San Antonio Supply & Machinery Co., San Antonio, Tex., has been appointed agent for McClave-Brooks Co., Scranton, Pa., covering southern Texas and northern Mexico.

The Westinghouse Electric & Manufacturing Co., South Philadelphia, Pa., announces that C. E. Reese has been appointed general manager of the Bluefield Gas & Power Co., Bluefield, W. Va.

The Uehling Instrument Co., Paterson, N. J. has recently appointed the Ruggles-Klingemann Manufacturing Co., 200 Devonshire St., Boston, Mass., representative for its New England district.

The Condit Electrical Manufacturing Co., South Boston, Mass., announces the recent appointments of: Shook & Fletcher Supply Co., Birmingham, Ala., for the State of Alabama; Ward Engineering & Battery Co., Jacksonville, Fla., for the State of Florida; E. A. Thornwell, of Atlanta, Ga., for the State of Georgia.

The Hays Institute is the new name selected for the school formerly called the Hays School of Combustion, at 1412 South Michigan Ave., Chicago, Ill. Jos. W. Hays is preparing a fireman's course and a janitor's course in which practical problems rather than those requiring the use of mathematics will be the basis of the examinations.

The Johns-Manville, Inc., 294 Madison Ave. at 41st St., New York City, manufacturers of asbestos materials and power plant specialties, at a recent meeting elected the following officials: T. F. Manville, chairman of the board; H. E. Manville, president; L. H. Hoff, vice-president and general manager; W. R. Seigle, vice-president and general manager of mines and factories; J. E. Meek, J. W. Perry, J. S. Carroll, vice-presidents; A. C. Hoyt, secretary and treasurer; T. F. Mandeville, Jr., assistant secretary and treasurer.

Trade Catalogs

Steam Heating—Warren Webster & Co., Camden, N. J. Booklet "Webster from the Air," gives many illustrations of cities viewed from above.

Meters—Bailey Meter Co., 2015 East 46th St., Cleveland, Ohio. Bulletin No. 9 describes various types of meters, panel boards, etc., manufactured by this company.

Pumping Equipment — De Laval Steam Turbine Co., Trenton, N. J. Leaflet "Pumping Station for Allentown, Pa.," shows numerous views of this installation.

Diesel Oil Engines—Lombard Governor Co., Ashland, Mass. Bulletin No. 21-S shows the structure and workings of these engines by means of numerous illustrations and concise text.

Valves—Homestead Valve Manufacturing Co., Homestead, Pa. Catalog No. 31 is well illustrated and contains tables and data that should be useful to persons interested in ordering valves.

Packing—Palmyra Packing Co., Palmyra, N. Y. Catalog B-1924 contains 47 pages of information, with good illustrations, of the styles, sizes and uses of the packing manufactured by this company.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Mar. 17, 1924	Mar. 24, 1924
Pool 1	New York	$3.25	$3.25
Smokeless	Columbus	2.25	2.25
Clearfield	Boston	2.60	2.50
Somerset	Boston	4.75	2.75
Kanawha	Columbus	1.65	1.70
Hocking	Columbus	2.00	1.85
Pittsburgh No. 8	Cleveland	1.90	1.90
Franklin, Ill	Chicago	2.50	2.50
Central, Ill	Chicago	2.25	2.25
Ind. 4th Vein	Chicago	2.50	2.50
West Ky.	Louisville	1.90	1.85
S. E. Ky.	Louisville	2.00	2.00
Big Seam	Birmingham	1.85	2.25

FUEL OIL

New York—March 27, light oil, tank-car lots, 28@34 deg. Baumé, 5c. per gal., 36@40 deg. 5½c. per gal., f.o.b. Bayonne, N. J.

St. Louis—March 19, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.90 per bbl.; 26@28 deg., $1.95 per bbl.; 28@30 deg., $2 per bbl.; 32@36 deg., gas oil, 5½c. per gal.; 36@40 deg., 6½c. per gal.

Pittsburgh—March 18, f.o.b. local refinery, 30@34 deg., fuel oil, 5½c. per gal.; 36@40 deg., fuel oil, 6c. per gal.

Cincinnati—March 25, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 6c. per gal.; 26@30 deg., 6½c. per gal.; 30@32 deg., 6¾c. per gal.

Dallas—March 21, f.o.b. local refinery, 26@30 deg., $1.30 per bbl.

Philadelphia—March 22, 28@30 deg., $2.31@$2.36 per bbl.; 18@22 deg., $2.10 @$2.16½; 13@16 deg., $1.68@$1.74½ per bbl.

Boston—March 24, tank-car lots, f.o.b. heavy oil, 12@14 deg. Baumé, 4½c. per gal., light oil, 28@32 deg. Baumé, 6½c. per gal.

New Plant Construction

Ala., Alexander City—The Home Ice Co., recently organized, has plans nearing completion for the construction of an ice-manufacturing plant with initial output of about 20 tons per day. It will be increased at a later date.

Ala., Fairfield — The Tennessee Coal, Iron & Railroad Co., Birmingham, Ala., will install additional steam boilers and other power equipment, including electric apparatus, in connection with proposed additions to its local steel mills, estimated to cost $4,000,000.

Ala., Florence—The United States Engineer Office will take bids until April 22 for 58 regulating gates for the Wilson Dam, Tennessee River, near Florence, as per specifications on file.

Ala., Little River—The Fort Payne Light & Power Co., Fort Payne, Ala., has secured permission for the construction of a hydro-electric generating plant at Desoto Falls, near Little River, estimated to cost in excess of $175,000. Plans will soon be drawn.

Ala., Troy—T. V. Ballard, Troy, is organizing a company to construct and operate a cold storage plant, estimated to cost close to $50,000, with equipment. J. A. Stallings, Henderson, Ala., is interested in the project.

B. C., Penticton—The Oliver-Osoyoos Irrigation District plans for the installation of electric-operated pumping equipment in connection with its proposed irrigation works, for which an appropriation of $400,000, has been arranged. F. H. Latimer is engineer.

B. C., Vancouver—The Powell River Co. has tentative plans under advisement for increasing the height of its power dam in the Powell River, for the installation of additional equipment at the hydro-electric generating plant. It is expected to increase the capacity from 25,000 to 50,000 hp.

Calif., Los Angeles—The Lincoln Ice Co. will begin the construction of a new one-story ice-manufacturing plant at 1737 West Albion St., with daily output of about 65 tons. A boiler plant will be constructed, with two 100 hp. boilers and auxiliary equipment. Hamm & Grant, 607 Ferguson Bldg., are engineers.

Calif., Marysville — The Yuba County Farm Bureau is considering preliminary plans for the construction of a series of ice and refrigerating plants in different sections of the county.

Calif., Oakland — The Illinois Wire & Cable Co., Sycamore, Ill., contemplates the construction of a boiler house at its proposed local plant on 6-acre tract of land recently acquired, to cost in excess of $125,000, with equipment.

Calif., Sacramento—The California Packing Company, 101 California Street, San Francisco, will build a power house, ice-manufacturing and cold storage plant at its proposed local fruit packing plant at Sixteenth, B and C Streets, estimated to cost $1,000,000. Philip L. Bush is company engineer.

Calif., San Diego—The Board of Public Works plans for the installation of electric-operated pumping machinery in connection with the proposed development of a water supply on the San Diego River, estimated to cost $3,500,000. A special election to vote bonds has been called April 29. F. A. Rhodes is city engineer.

Colo., Denver—The Colorado Fuel and Iron Co. will spend $3,000,000 during the year 1924 for modern improvements at its steel plant at Minnequa, Colo. High pressure boilers and superheaters, turbo-blowers to replace reciprocating steam engines, electric auxiliary equipment, and electrical precipitators for elimination of dust and other impurities from artificial gas made at the plant, will be some of the items needed.

Conn., Stamford—The H. E. Verran Co., 19 Union Square, West, New York, plans for the construction of a boiler house and pumping plant at its proposed local lace mills, to cost about $150,000. Lockwood, Greene & Co., 101 Park Ave., New York, are architects and engineers.

D. C., Washington—The general purchasing officer, Panama Canal, will take bids until April 14, for one air compressor, expansion joints and other equipment, specified in Circular 1598.

D. C., Washington — The Washington Suburban Sanitary Commission, 1420 New York Ave., N. W., T. Howard Duckett, chairman, contemplates the installation of electric-operated pumping machinery in connection with proposed extensions in water and sewerage systems in Montgomery and Prince George Counties, Md., to cost approximately $1,000,000. R. B. Morse, Hyattsville, Md., is chief engineer.

Fla., Apopka—The Consumers' Mill Co. is reported to be planning for the rebuilding of the portion of its lumber mill and power house, recently destroyer by fire with loss of about $45,000.

Fla., Bradentown—R. L. Dowling & Son have preliminary plans for the rebuilding of the portion of their lumber mill and power house recently destroyed by fire with loss reported at $300,000, including equipment.

Fla., Rio — The Rio Lumber Co., Fort Pierce, Fla., T. H. Banes, general manager, plans the construction of a power house at its proposed mill in this district, which will have a monthly output of about 500,000 sq.ft., estimated to cost in excess of $200,000, including equipment. The company is a consolidation of the Ford Lumber Co., Indianrio, Fla., and the Pineda Lumber Co., Pineda, Fla.

Ga., Doctortown—The Case-Fowler Lumber Co., Macon, Ga., plans for the construction of a power house at its proposed local saw and lumber mill, estimated to cost in excess of $85,000, including equipment.

Ga., McRae—The Common Council has preliminary plans for the construction of a municipal electric power plant, steam-operated. An appropriation will be arranged at an early date.

Ga., Thomasville — Bids will be asked during April for a refrigerating plant for the new Archbold Memorial Hospital buildings to be constructed on local site, for which foundations will soon be laid. Eugene C. Wachendorff, Forsyth Bldg., Atlanta, Ga., is architect in charge.

Ind., Shelbyville—Edward C. Newton and Ernest G. Reece, both of Shelbyville, contemplate the installation of a boiler plant at their proposed local canning factory, estimated to cost $45,000.

Ind., Shelbyville—The Flat Rock Hydro-electric Power Co. has filed application with the Public Service Commission for permission to commence the construction of its proposed hydro-electric power plant on the Flat River. Clarence C. Shipp, Indianapolis, Ind., heads the company.

Ky., Louisville — The Floyd County Tuberculosis Hospital Association plans for the construction of a boiler plant at the proposed new hospital on property acquired on the Old Vincennes Road, to cost in excess of $350,000.

La., Shreveport—The Ideal Laundry & Dry Cleaning Co., 1019 Travis St., is planning for the purchase of an electric generator, about 40 kw., direct-connected to a natural gas engine, with auxiliary equipment, for its power house.

Man., Winnipeg—A group of mining interests in the northern part of Manitoba are arranging plans for the construction of a hydro-electric power plant on the Grass River, to be used for ore mill operation and other mining service, for which a large fund is being subscribed. The American Consulate Office, J. I. Brittain, consul general, Winnipeg, has information regarding the project.

Md., Frederick — The Frederick County Products Co., Inc., will soon begin the construction of a one-story ice and refrigerating plant, estimated to cost $65,000. Col. P. M. Anderson, Southern Bldg., Washington, D. C., is architect.

Mass., Boston—The City Hospital Department, Joseph P. Manning, president, 818 Harrison Ave., has preliminary plans in preparation for the construction of an addition to the power house at the city hospital. It is proposed to install an engine and other equipment. Ritchie, Parsons & Taylor, 15 Ashburton Place, are architects.

Mich., Frankfort — The Benzie County Power Co. has tentative plans for extensions in its hydro-electric power plant on the Betsey River, including the installation of additional equipment.

Mich., Jackson — The Board of Public works contemplates the installation of electric-operated pumping equipment at its proposed sewerage disposal works, estimated to cost $1,000,000. Hoad, Decker, Shoecraft & Drury, 303 State St., Ann Arbor, Mich., are engineers.

Mich., Three Rivers—The Michigan Artificial Ice Co. is perfecting plans for the construction of an ice-manufacturing and cold storage plant on local site, reported to cost close to $100,000, with equipment. The Michigan Central Railroad Co. is interested in the project.

Mont., Ryegate—The Board of County Commissioners contemplates the installation of an electric-operated pumping station in connection with its proposed Franklin irrigation project, on which it is expected to commence work in the spring. W. O. Wood is county clerk.

Neb., Howells—The Village Council is considering the installation of electric-operated pumping machinery at its proposed sewerage disposal works, estimated to cost $35,000. George Lodes is village clerk.

N. J., Newark—The Associated Utilities Co., 30 Church St., New York, expects to complete plans early in May for an eight-story ice-manufacturing and cold storage plant at 56 Center St., 105 x 167 ft., to cost in excess of $800,000, with equipment. John Decker, 19 Ridgeview Ave., West Orange, N. J., is architect.

N. Y., Brooklyn—The Bureau of Supplies and Accounts, Navy Department, Washington, D. C., will take bids until April 8, for one boiler for the local navy yard, as set forth in Schedule 2010.

N. Y., Buffalo — William F. Schwartz, Municipal Bldg., commissioner of public works, will take bids at once for a number of air compressors, pumps and auxiliary equipment for the department of water.

N. Y., New York — The Fox-Geldberg Holding Corp., 280 Madison Ave., plans to take bids in about four weeks for the erection of its proposed ten-story ice and refrigerating plant on Washington St., to be 140 x 250 ft., estimated to cost $1,250,000, with machinery.

N. Y., Oswego — The Oswego Candy Works, Inc., is planning for the construction of a boiler plant in connection with its proposed three-story factory, 50 x 100 ft., estimated to cost $80,000, with equipment.

New Zealand, Auckland—The Auckland Power Board has plans under way for the construction of a power dam at Arapuni Rapids, Waikato River, with the installation of three hydro-electric generating units, totaling 45,000 kw., to be completed within 48 months.

N. C., Rockingham—The Hannah Pickett Mills, Inc., will construct a steam-operated electric power plant with initial capacity of 1,700 hp., in connection with a number of additions to its textile mills, to cost about $250,000. The power station will approximate $50,000.

N. C., Sanford—The Makepeace Box & Lumber Co. plans for the purchase of a Corliss engine, about 150 hp. capacity, with auxiliary equipment, for installation at its power house.

N. C., Spruce Pine—Norman G. Smith & Co., Inc., an interest of the Maine Feldspar Co., Brunswick, Me., plans for the construction of a steam power plant at its local kaolin properties. The greater part of the machinery installed will be electric-operated

N. C., Star—The Common Council is having plans prepared for the installation of a waterworks system, to include an electric-operated pumping plant. Beebe & Co., Spartanburg, S. C., are engineers.

N. D., Grand Forks—The City Council has called a special election on April 1, to vote bonds for $110,000 for a municipal electric power plant, for which plans will soon be drawn. Charles M. Evanson is city

Ohio, Osborn — The Wabash Portland Cement Co., 1824 Ford St., Detroit, Mich., operating a mill at Stroh, Ind., plans for the construction of a power house at its proposed local plant, to cost approximately $1,250,000. H. F. Jennings is secretary.

Ohio, Leetonia—The Cherry Valley Furnace, operating a local blast furnace and steel works, plans for the construction of a new steam power house in connection with plant expansion, including the installation of a battery of six water-tube boilers and auxiliary equipment, engines, etc.

Ohio, Warren—The American Roll & Machine Co., recently organized, contemplates the construction of a steam power house at its proposed local plant in the Leavittsburg section, estimated to cost $275,000. R. E. Shook and J. B. Estabrook, Warren, head the new company.

Ohio, Cincinnati—The United States Engineer Office will receive bids until April 7 for the construction of power houses at Dams Nos. 34, 36 and 38, Ohio River, as per plans and specifications on file.

Okla., Wewoka — The Common Council contemplates the installation of electric-operated pumping machinery in connection with extensions in the municipal waterworks, for which tentative estimates of cost are being made by V. V. Long & Co., Oklahoma City, Okla., engineers.

Ore., Corvallis — The City Council has tentative plans for extensions and improvements in the municipal water system, utilizing water from Rock Creek, to include the installation of electric-operated pumping equipment, estimated to cost $327,000. Stevens & Coon, Portland, Ore., consulting engineers, have submitted a preliminary report.

Ore., Eugene—The City Council has made application for permission to use waters from the McKenie River for a municipal hydro-electric development.

Ore., Freewater—H. S. Freeman, Freewater has made application to the state water department for permission to construct and operate a hydro-electric generating plant on the Walla Walla River, with initial capacity of 1,275 hp., estimated to cost $140,000. It is said that a company will be formed to operate the station.

Ore., La Grande — The Bowman-Hicks Lumber Co. plans for the construction of a steam power house at its proposed local mill, estimated to cost $100,000, including equipment.

Pa., Kutztown—The Common Council has called a special election on April 22, to vote bonds for $20,000, to apply towards the purchase of the local power plant of the Fleetwood & Kutztown Electric Light, Heat & Power Co., to be operated in the future as municipal property. Extensions and betterments are planned.

Pa., Elizabethtown—The Borough Council is planning for the installation of electric-operated pumping machinery at its proposed sewerage disposal plant, for which bids are to be received about April 15. F. H. Shaw, Breneman Bldg., 53 North Duke St., Lancaster, Pa., is borough engineer.

Pa., Pittsburgh—The Moorhead Electric Machinery Co., 127 Water St., is said to be considering the purchase of two motor-generator sets, about 250 kw. capacity, with exciters and auxiliary equipment.

Pa., Philadelphia—The Board of Trustees, University of Pennsylvania, Thirty-fourth St. and Woodland Ave., has authorized bonds for $750,000, for the construction of the proposed steam power plant on the Schuylkill River, near the South Street bridge, for which plans have been completed. It will be used for heating and steam service exclusively.

Pa., Tullytown—The Charles Warner Co., Wilmington, Del., building supplies, is reported to be planning for the installation of a steam power house at its proposed local sand and gravel plant, estimated to cost $600,000.

R. I., Providence—The Board of Trustees, Rhode Island College of Education, has tentative plans for the construction of a new central steam power house at the institution in connection with other buildings. The State Legislature is considering an appropriation of $600,000 for the work. William R. Walker & Son, Providence, are architects.

Sask., Prince Albert—Ernest F. Webb, city clerk, will take bids until May 15, for one 1,500 kw. steam turbo-generator, with condenser and accessories complete, as per specifications at the office of J. Jonsson, superintendent of utilities.

S. C., Summerton—The Town Council plans for the installation of electric-operated pumping equipment at the proposed municipal waterworks and sewerage plant, for which plans will be drawn by the Tomlinson Engineering Co., Columbia, S. C.

S. D., Woonsocket—The Schuler Electric Co. has authorized plans for the construction of a steam-operated electric power plant, to be operated in conjunction with its present station. Max McGraw, the McGraw Co., 515 Fifth Street, Sioux City, Iowa, is engineer.

Tenn., Jackson—The Central Oil Mill Co. is said to be planning for the rebuilding of the portion of its plant and power house, recently destroyed by fire with loss of about $120,000, including equipment.

Tenn., Knoxville—The Vestal Lumber & Mfg. Co., Knoxville, plans for the construction of a steam power plant at its proposed mills on 10,000-acre tract of land acquired in Southern Georgia, to cost in excess of $150,000.

Tenn., Crab Orchard — The Southland Portland Cement Co., 313 Independent Life Bldg., Nashville, Tenn., is perfecting plans for the construction of its proposed local cement mill, to include a steam-operated power plant. The project will involve close to $900,000. James O. Parker is president.

Tex., Caldwell—The Western Public Service Co., Calvert, Tex., has acquired the local plant of the Caldwell Electric & Ice Co., and plans for extensions, including the installation of additional equipment. The plant of the Kosse Light & Power Co., Kosse, in this same section, has also been taken over and will likely be dismantled.

Tex., Conroe—The Common Council plans for the installation of electric-operated pumping equipment in connection with a new waterworks, for which a bond issue of $40,000, is being arranged. F. S. Von Zuben, Fort Worth, Tex., are consulting engineers.

Tex., Denison—The City Council is considering the installation of electric-operated pumping machinery in connection with proposed extensions in the municipal waterworks, estimated to cost $50,000. Plans will soon be prepared.

Va., St. Petersburg — The Stockdell-Meyers Hardware Co., Inc., 28 South Sycamore St., plans for the purchase of power equipment, including two generators, 300 kw. capacity each, belt-driven type and 50-in. mechanical exhaust fan.

Va., Alberta—The Alberta Planing Mill Co. plans for the purchase of an oil-operated engine for installation in its power house, with auxiliary equipment.

Wash., Mount Vernon—The Pacific Fruit & Produce Co. has plans under way for the erection of a one-story cold storage plant at Third and Montgomery Sts., estimated to cost $28,000.

Wash., Seattle—The Bureau of Supplies and Accounts, Navy Department, Washington, D. C., will take bids until April 15, for 3,850 pounds of condenser tubes for the Puget Sound navy yard, as specified in Schedule 1,994.

Wash., Spokane — Mark F. Mendenhall and associates plan for the construction of a power house at a proposed pulp mill in this vicinity, estimated to cost $750,000, with equipment. The local Chamber of Commerce is interested in the project.

Wash., Tacoma—The City Commissioner of Light and Water, Room 402, will take bids until April 16, for equipment for the Cushman power project, including two water turbines, each with maximum capacity of 27,500 hp.; two generators, vertical type, each with capacity of 20,000 kva., with two direct-connected exciters and accessory apparatus; one electric synchronous condenser, 15,000 kva. capacity, with direct-connected exciter and auxiliary equipment; transformers; oil-testing sets, etc., all as per plans and specifications on file. J. L. Stannard is chief engineer.

W. Va., Huntington—The United States Engineer Office will soon take bids for the construction of a power house at Dam No. 32, Ohio River, for which plans have been authorized by the Chief of Engineers, Washington, D. C.

W. Va., Huntington—The Minter Homes Co., manufacturer of knock-down houses for housing developments, is reported to be planning for the construction of a steam power plant in connection with the rebuilding of the portion of its works, destroyed by fire March 19, with loss estimated in excess of $350,000.

W. Va., Westmoreland—The Huntington Sash & Cabinet Co., Huntington, W. Va., recently organized, plans for the construction of a power house at its proposed local mill. B. L. Winters is general manager.